Essays in Applied Macroeconomics

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Preface

The four years that I have spent as a PhD student at the University of Zurich have been an invaluable experience that has made me grow personally and professionally. During this time, I have learned a lot – not only about Economics, but also about myself. I wish to express my heartfelt gratitude to those who have contributed to this thesis and to those who have accompanied me on this journey. Without them, this dissertation would not have been possible.

First of all, I would like to thank my advisor, Fabrizio Zilibotti, for his guidance, for his support, and for giving me the freedom to pursue my desired research projects. He is a truly inspiring person, and I am impressed by his immense knowledge and by his ability to quickly grasp the essence of a topic, even if it does not fall into his particular area of expertise. My sincere thanks also go to my co-advisor, Mathias Hoffmann, for his insightful comments and for his encouragement. I highly appreciate that he always took the time to discuss my research with me.

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Last but not least, I would like to express my deepest appreciation and thanks to my partner, Nils Baier, who has been by my side at every step of this journey. Words cannot express how grateful I am to him for all his love and support. He has never stopped believing in me, and he has spent many sleepless nights encouraging me.

Beatrice Kraus, Zurich, August 2015

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Part I

Dissertation Overview

Dissertation Overview

This dissertation consists of three essays in the field of Applied Macroeconomics. The first two essays analyze the transmission of tax changes empirically and theoretically. The third essay explores the effect of exchange rates on tourism in Switzerland.

The *first essay* is joint work with Christoph Winter. In this essay, we demonstrate that tax changes affect financial market conditions in the data. For this purpose, we conduct a VAR analysis using the Romer and Romer (2010) narrative record of exogenous tax changes in the US. We find that a tax increase drives up risk premia for corporate bonds issued by financial and non-financial firms. In a next step, we argue that balance sheet conditions of financial intermediaries act as a channel for the transmission of tax changes to financial markets. In line with the recent literature on intermediary asset pricing, we empirically document that risk premia depend on intermediaries' balance sheet conditions, which are also affected by taxes. Strikingly, our results are not driven by tax acts targeting the financial sector. This implies that any tax change can have substantial effects on financial market conditions, which in turn may influence its overall impact on real economic activity.

The *second essay*, which is also joint work with Christoph Winter, is based on the fact that the previous literature finds significant empirical tax multipliers for real economic activity. The effects are especially large for durables purchases and investment. In this essay, we show that a model with standard tax distortions is not able to explain the large empirical impact of taxes on these two variables. We then quantify the additional investment wedges needed in an augmented RBC model in order to match the size of the empirical tax multipliers for durables purchases and investment. Our results have important implications for the modeling of the transmission of tax changes. Based on our findings, we conclude that the right model should allow for separate durables and capital investment wedges, which should both be positively affected by tax changes. As a further contribution, we discuss possible microfoundations for this type of wedges, and we argue that financial frictions are obvious candidates. To the extent that this is the case, our results provide useful guidance for the construction of models with financial frictions.

In the *third essay*, I estimate exchange rate elasticities for tourism in Switzerland. For this purpose, I develop a new estimation approach that can also be applied to other countries. My identification strategy is based on effective exchange rates, which in turn are determined by the relative share of tourists from different countries of origin. Due to regional variation in these shares, the tourism sector of each canton in Switzerland is exposed to a different basket of bilateral exchange rates. This allows me to estimate the effect of exchange rates on tourism in a panel error correction model. I find long-run exchange rate elasticities for arrivals, overnight stays, bed and room occupancy rates, and revenues per available room between 0.47 and 1.54, with an adjustment speed that lies between 30 and 56 percent. My results are highly robust to different measures of my explanatory variables and to a wide range of alternative specifications.

The common component of all three essays is their relevance for policy making. The first essay demonstrates that it is crucial to take into account the reaction of financial markets when assessing the consequences of tax changes. This has been particularly important during the recent financial crisis, which originated in financial markets. Fiscal policy, and especially tax changes, were a widely-used instrument in the mitigation of the adverse effects of the crisis. Our results suggest that tax changes themselves can spill over to financial market conditions, which consequently affect real economic activity. This additional channel increases the potential impact of taxes. However, it also illustrates the complexity of the mechanisms at work. The results from the second essay demonstrate that this spillover has direct consequences for the modeling of the transmission of tax changes. Specifically, conventional models – which often serve as a basis in political decision making – need to be augmented by additional investment frictions. Only then are they able to successfully predict the impact of taxes on the economy, and only then can they provide reliable advice for policy makers.

Whereas the first two essays focus on taxation, the third essay analyzes the impact of exchange rates on tourism. Especially in Switzerland, this has been a highly discussed topic recently. As a safe haven currency, the Swiss franc has experienced a strong appreciation during and after the Great Recession. My findings suggest that the tourism sectors in different Swiss cantons are able to reduce the negative impact of this appreciation by targeting tourists from different countries of origin. However, there is also a large common component that drives the effective exchange rates of all cantons. Therefore, additional policies that address the problem on a more aggregate level are necessary in order to combat the adverse effects of the strong Swiss franc on tourism.

The results from all three essays demonstrate that the effects of public policies can be diverse and are not necessarily straightforward. There are direct as well as indirect channels, and the impact may vary across different geographical regions. Policy makers should take all of these aspects into account when making their decisions.

Part II

Research Papers

1 Do Tax Changes Affect Credit Markets and Financial Frictions? Evidence from Credit Spreads

Joint with Christoph Winter

1.1 Introduction

The general topic of the first two papers in this thesis is the transmission of tax changes. Specifically, we use two different, complementary approaches to show that taxes affect investment wedges caused by financial frictions, which in turn have an impact on real economic activity. In the present paper, we analyze this question from an empirical point of view, whereas in the second paper, we take a theoretical approach.

Our empirical analysis is motivated by the recent financial crisis. The widespread view is that the crisis originated in financial markets. Moreover, fiscal policy, and in particular tax changes, played a decisive role in the combat of the adverse effects of the crisis on the real economy. What if financial market conditions are themselves influenced by fiscal policy changes? And if so, what are the effects of tax policy changes on financial market conditions and on credit supply?

In this paper, we show that there is indeed a tight connection between tax policy changes and financial markets. Using VARs, we document that exogenous tax changes have a sizeable impact on corporate bond spreads. We identify exogenous tax changes in the US for the post-World War II period using the narrative account by Romer and Romer (2010). In order to avoid anticipation effects, we focus on unanticipated tax changes, in the spirit of Mertens and Ravn (2012).

We find that an increase in tax liabilities by one percent of GDP raises corporate bond spreads by between one and two percentage points, depending on the measure used. Interestingly, when we distinguish between corporate and personal income tax adjustments using information from Mertens and Ravn (2013), we find that corporate bond spreads respond to both types of tax changes. This finding rules out that credit spreads only respond to tax changes because firms alter their mix of equity and debt financing in order to avoid higher corporate income taxes. Moreover, since the Romer and Romer (2010) narrative record ends in 2006, and therefore does not include the Great Recession, our results imply that even in 'normal' times, tax liability changes and financial market conditions are linked.

We know from the previous literature that an increase in tax liabilities has large contractionary effects on real economic activity, in particular on GDP and investment, see e.g. Romer and Romer (2010), Mertens and Ravn (2011, 2012, 2013), and most recently Ramey (2015). Since corporate bond spreads are negatively correlated with real economic activity (see e.g. Gilchrist and Zakrajsek 2012), the response of corporate bond spreads to an increase in tax liability changes could simply be the by-product of the adverse response of various economic measures to an increase in taxes.[1] To address this concern, we use the excess bond premia of financial and non-financial corporate firms, as constructed by Gilchrist and Zakrajsek (2011, 2012). Gilchrist and Zakrajsek (2011, 2012) decompose the spread between the yields of corporate bonds and Treasuries of the same maturity and payment structure into two components: one that captures the countercyclical movements in expected default rates and another component measuring the procyclical variations between the expected default risk and the credit spread. This latter component is what Gilchrist and Zakrajsek (2011, 2012) call the excess bond premium. By construction, the excess bond premium measures the willingness of the market to accept default risk of corporate firms, i.e. the effective risk aversion.

Recent empirical and theoretical evidence suggests that financial intermediaries are central for understanding the behavior of corporate bond spreads (see e.g. Collin-Dufresne, Goldstein, and Martin 2001). In turn, the risk appetite of financial intermediaries seems to be determined by their balance sheet conditions (see e.g. the theoretical models by He and Krishnamurthy 2013 and Brunnermeier and Sannikov 2014).[2] Adrian, Moench, and Shin (2010), Adrian and Shin (2010a), and Adrian, Colla, and Shin (2012) provide empirical evidence on the link between risk premia and intermediaries' balance sheet conditions. The finding from this strand of literature regarding the link between intermediaries' balance sheet conditions, their effective risk aversion and excess bond premia has important consequences for our analysis, since it implies that tax changes that have an impact on excess bond premia should also affect measures of the stance of intermediaries' balance sheets, such as their return on assets.

We evaluate this hypothesis using the 'dummy variable approach' by Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004), who analyze the impact

[1] As Philippon (2009) makes clear, even in the absence of financial frictions, corporate bond spreads react to changes in expected default risk.

[2] Brunnermeier, Eisenbach, and Sannikov (2012) survey the theoretical literature.

of government spending on economic activity. We use this approach to disentangle the overall effect of taxes into the contribution of specific tax acts. This allows us to analyze *whether* financial intermediaries' balance sheet conditions respond to the same tax acts as excess bond premia. Moreover, using detailed information about each tax act, we can also determine *why* the financial intermediaries' return on assets (and therefore excess bond premia) react after a specific tax act.

We find that intermediaries' balance sheet conditions and excess bond premia simultaneously respond to two tax acts, namely to the Tax Reform Act (TRA) of 1986 and to the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) of 2003. The 1986 TRA affects intermediaries' balance sheet conditions because it leads to an increase in the fraction of non-performing loans. We relate this increase to the adverse effects of the 1986 TRA on capital-intensive industries such as mining (see Cutler 1988).

On the other hand, the 2003 JGTRRA has a major impact on personal income taxes, in particular on the taxation of dividends and capital gains. In line with a large literature that finds that changes in dividend/capital gain taxes have an impact on stock prices (see Sialm 2009), we document that the 2003 JGTRRA has a significant effect on equity valuations.[3] Corporate equity is the second largest asset in balance sheets of the financial industry. We therefore conclude that the 2003 JGTRRA affects intermediaries' balance sheet conditions via changes in stock prices. Indeed, we find that the overall impact of personal income tax changes on equity valuations, the intermediaries' return on assets, and excess bond premia is entirely driven by the 2003 JGTRRA.

In conclusion, our results suggest that the rise in excess bond premia after an increase in tax liabilities indicates strains in the financial sector, which might have general implications for the supply of credit, both through the corporate bond market and through the banking sector in general.

Our paper therefore contributes to the growing literature that documents possible linkages between fiscal policy and financial market conditions, see e.g. Fernández-Villaverde (2010), Carrillo and Poilly (2013), Melina and Villa (2014), Canzoneri et al. (2015), Ji and Qian (2015), and Röhrs and Winter (2015). The focus of most of these papers is on government spending multipliers (see Carrillo and Poilly 2013, Melina and Villa 2014, and Canzoneri et al. 2015) or on government debt (see Röhrs and Winter 2015). Moreover, with the exception of Melina and Villa (2014) and Ji and Qian (2015), none of these papers empirically documents that fiscal policy and financial markets are linked.

Our work is also related to several other strands of literature. First, we contribute to the literature that analyzes the consequences of tax liability changes, see the survey by Ramey (2015). So far, the focus of the previous papers has been exclusively on the real

[3]See also Auerbach and Hassett (2005, 2006) for related evidence.

part of the economy. Our results suggest that tax changes also have an impact on the financial sector.

Second, our findings are also relevant for the question of whether the contractionary effects of tax increases are determined on the 'supply' or on the 'demand' side of the economy. By showing that credit supply conditions are important, our evidence points to the relevance of supply side conditions. In macro models with financial frictions, such as the financial accelerator mechanism proposed by Bernanke and Gertler (1995), Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999), Gertler and Kiyotaki (2010), and Hall (2011), a tightening of these frictions adversely affects credit supply, with substantial consequences for aggregate economic variables.[4] Our results may therefore help to explain the large contractionary responses observed after a tax increase.

Third, the results in our paper contribute to the literature that is interested in understanding the consequences of prominent tax acts, such as the 1986 TRA and the 2003 JGTRRA, see e.g. Cutler (1988), Poterba (1992), or Auerbach and Hassett (2005, 2006). We document new channels through which these tax acts affect the US economy, which have not been considered by the previous literature.

Fourth, we contribute to the literature that analyzes the importance of financial intermediaries and their balance sheet conditions for economic activity in general and, more specifically, for asset pricing, see e.g. Gertler and Kiyotaki (2010), He and Krishnamurthy (2013), and Brunnermeier and Sannikov (2014). We show that intermediaries' balance sheet conditions matter for the transmission of tax changes, even if these tax changes do not directly target the financial sector.

And last but not least, by documenting that tax changes can lead to large, albeit infrequent, deviations of corporate bond prices relative to the expected default risk, we contribute to the literature that attempts to explain the 'corporate bond puzzle' (see e.g. Collin-Dufresne, Goldstein, and Martin 2001).

The remainder of this paper is structured as follows. In Section 1.2, we describe our data for tax changes and excess bond premia. In Section 1.3, we discuss our estimation strategy. The responses of excess bond premia to tax changes are shown in Section 1.4. In Section 1.5, we argue that financial intermediaries' balance sheet conditions are important for understanding the behavior of excess bond premia. In Section 1.6, we analyze whether tax changes also have an impact on measures of the condition of intermediaries' balance sheets. For this purpose, we take a more disaggregate view and analyze the impact of personal and corporate income tax changes separately. Moreover, we also disentangle the impact of specific tax acts. Finally, Section 1.7 concludes.

[4] See Quadrini (2011) for a recent survey.

1.2 Data: Tax Changes and Excess Bond Premia

This paper documents a novel link between tax changes and credit spreads. In this section, we describe how changes in tax liabilities and excess bond premia are measured.

1.2.1 Identification of Exogenous Tax Shocks: The Romer and Romer (2010) Narrative Approach

In order to identify the impact of discretionary tax changes, we make use of the Romer and Romer (2010) narrative record of federal tax changes in the US between 1945 and 2007. Romer and Romer (2010) classify each tax act according to four categories of motivation: spending-driven (e.g. due to war), countercyclical, deficit-driven (to reduce inherited budget deficits), and to raise long-run growth (e.g. improve incentives, reduce inefficiencies). They argue that spending-driven and countercyclical tax changes are endogenous because they are correlated with other forces affecting output in the short run. Tax events that belong to the other two categories, on the other hand, can be seen as exogenous, since they are not motivated by current or prospective short-run economic conditions. Using this classification, Romer and Romer (2010) construct a quarterly dataset of exogenous tax changes.[5] The size of each tax change is defined as its impact on annual tax liabilities in percent of current GDP. The dataset contains 54 exogenous tax liability changes that are the result of 35 tax acts.

We only use those tax liability changes that are 'unanticipated'. We will discuss the reason for this in greater detail in the following paragraph.

Avoiding anticipation effects. When looking at tax changes, it is important to be aware of anticipation effects. This has, among others, been pointed out by Mertens and Ravn (2012), Leeper, Richter, and Walker (2012), and Yang (2007). In our context, the issue of anticipation effects is even more pressing, since we work with market-determined interest rates, which can react instantaneously to news about future tax changes.

Therefore, we only use the exogenous tax changes in the Romer and Romer (2010) dataset that were 'unanticipated'. Our definition is inspired by Mertens and Ravn (2012), who classify a tax change as unanticipated if there are no more than 90 days between the announcement and implementation date (where the announcement date is the day on which the tax became law, i.e. when it was signed). For our purpose, we are even stricter and treat a tax change only as unanticipated if the implementation and announcement

[5] See also their companion paper, i.e. Romer and Romer (2009).

date are less than 30 days apart.[6] As a robustness check, we also create a time series that follows the Mertens and Ravn (2012) definition. It turns out that our results are robust to different definitions of unanticipated tax acts.

In that context, it is important to note that we use a slightly different timing convention than Romer and Romer (2010) and Mertens and Ravn (2012). Specifically, Romer and Romer (2010) assign a tax change that takes place in the second half of a quarter to the following quarter. As we are dealing with interest rates, which are expected to react even within the same day, we assign every tax change to the quarter it actually happened in.[7]

As a result of these adjustments, our dataset contains 21 unanticipated tax liability changes that derive from 21 different tax events. Exact details about the timing, the size, and the categorization of every tax change are given in Tables 1.A.1 and 1.A.2 in the Appendix. Figure 1.A.1 presents the data.

Finally, we test whether there are signs that our series of unanticipated tax events was nevertheless anticipated by the market. For this purpose, we construct the yield spread between Treasuries and municipality bonds, using data from Leeper, Richter, and Walker (2012). Treasuries are subject to federal income taxation, whereas municipality bonds are not. The spread between the two bonds should therefore reflect market expectations of the present value of tax changes over the maturity of the bond. If tax changes were anticipated, we should therefore find that their incidence can be predicted by the municipality bond spread. However, this is not the case. Specifically, we cannot reject the null hypothesis that the municipality spread does not Granger cause our narrative series of unanticipated tax shocks.

1.2.2 Excess Bond Premia: EBP and FBP

Data on excess bond premia are taken from Gilchrist and Zakrajsek (2011) for financial firms and from Gilchrist and Zakrajsek (2012) for non-financial firms.[8] Gilchrist and Zakrajsek (2011, 2012) construct individual corporate bond spreads for non-financial and for financial firms using micro-level data for a large sample of US firms. For each firm, the spread is defined as the difference in the yield of senior, unsecured bonds and a synthetic

[6]Note that for the announcement date, we have the exact day, whereas for the implementation date we only know the month. Assuming that the implementation always happened at the beginning of the month, we also count those tax acts as 'unanticipated' for which the implementation month is in the month after the announcement date. In a robustness check, we only count those tax acts for which the announcement month and the implementation month are the same. Reassuringly, this does not change our results.

[7]In Section 1.6, we distinguish between personal and corporate tax changes. For this purpose, we use the dataset by Mertens and Ravn (2013) and therefore follow their timing convention.

[8]We thank the authors for making their data publicly available.

risk-free asset. The synthetic risk-free asset is constructed such that its cash flows exactly match the payment structure of the corresponding corporate bond.

Gilchrist and Zakrajsek (2011, 2012) then decompose the spread for each firm into a component that captures the countercyclical movements in default risk and a procyclical residual, which measures the willingness of the market to accept default risk. This latter component is labeled as excess bond premium. In the following, we denote the average excess bond premium for non-financial firms as EBP and the average excess bond premium for financial firms as FBP. EBP is available from 1973Q1 onwards. The time series for FBP starts in 1985Q1.

Relative to other corporate bond spreads that are commonly used in the literature, such as the spread between yields of Aaa-rated corporate bonds and Treasuries, the excess bond premia have two key advantages. First, they are constructed using micro-level data, whereas other corporate bond spreads are typically based on aggregate data only. The aggregate approach makes it impossible to compare the payment structure, maturity etc. of the financial instruments. EBP and FBP, on the other hand, are not subject to this maturity mismatch.

The second key advantage is that the excess bond premia can be interpreted as evidence for the existence of 'financial frictions'. As noted by Philippon (2009), even in the absence of financial frictions (i.e. in a world in which the Modigliani-Miller Theorem holds), the prices of corporate bonds, and therefore corporate bond spreads, depend on default risk (i.e. the amount of corporate debt).[9] The high predictive power of excess bond premia, in particular of EBP, for real economic activity can be interpreted as further evidence for the fact that excess bond premia signal the strength of 'financial disruptions', see Gilchrist and Zakrajsek (2012). In Section 1.5, we will elaborate more on the link between excess bond premia and financial frictions.

1.3 Estimation

Before we proceed to our results, we discuss our estimation procedure in this section.

Baseline VAR. Following Favero and Giavazzi (2012), Mertens and Ravn (2011, 2012), and Cloyne (2013), we estimate the following reduced-form VAR:

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=0}^{s} B_j x_{t-j} + D + Et + u_t \tag{1.1}$$

[9] According to the Modigliani-Miller Theorem, the value of a firm is independent of the capital structure, but not the price of corporate bonds (see Modigliani and Miller 1958).

where y_t is the vector of endogenous variables, and the exogenous variable x_t is given by Δtax_t, the narrative account for the exogenous, unanticipated tax liability changes in quarter t, relative to GDP in the same quarter. In the exogenous part of the VAR, we also include a constant D and a linear time trend with coefficient matrix E.

Using our reduced-form VAR, we can compute the dynamic multipliers, i.e. the responses of the endogenous variables to exogenous tax liability changes. Following Lütkepohl (2006), Chapter 10, we rewrite the reduced form as:

$$A(L)y_t = B(L)x_t + u_t$$

using the following definitions: $A(L) := I_K - A_1L - ... - A_pL^p$ and $B(L) := B_0 + B_1L + ... + B_sL^s$. The final form of the system is then given by

$$y_t = D(L)x_t + A(L)^{-1}u_t$$

where $D(L) := A(L)^{-1}B(L)$ is the dynamic multiplier.

We estimate the system given in Specification (1.1) using quarterly data. The vector y_t consists of the logarithm of GDP, nondurables consumption (including services), durables consumption and private investment. We divide all variables by their respective deflator and by population. In addition, we also include the logarithm of hours worked and the ratio of federal tax revenues/GDP. Later, we will augment the system with additional endogenous variables, such as e.g. measures of excess bond premia. A detailed description of all variables is provided in Table 1.A.3 in the Appendix.

Note that the concept of exogeneity imposed by Romer and Romer (2010) for the selection of tax liability changes does not necessarily correspond to the definition of exogeneity applied in Specification (1.1). The econometric definition of exogeneity requires that past changes of observable variables have no predictive power for tax changes. An additional requirement is that tax changes should not contemporaneously respond to other variables. The first assumption can be formally tested. Romer and Romer (2010) and Mertens and Ravn (2012) analyze whether observable variables have predictive power for tax liability changes and conclude that there is no strong evidence for predictability. The second requirement is untestable. However, as noted by Mertens and Ravn (2011), "legislative lags make it very likely that contemporaneous causality runs from changes in tax legislation to observables and not vice versa" (page 29).

Also note that the results from Specification (1.1) should be interpreted as the average effect of exogenous tax changes. In Section 1.6, we will decompose this aggregate effect into the effects of corporate and personal income tax changes using information from Mertens and Ravn (2013). In addition, we will adopt the ‘dummy variable approach’ applied by Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004) to separate the impact of specific tax acts. Specifically, Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004) use narrative measures as exogenous variables in order to analyze government spending shocks, see also Ramey (2011). With this strand of literature, we share the approach to treat the narrative measure directly as the shock of interest, as in Specification (1.1).

Note that Specification (1.1) is just the reduced form, from which the structural form (which includes the instantaneous coefficients between the endogenous variables, see e.g. Lütkepohl 2006) cannot be identified without further assumptions.

Instead of using the narrative measure directly, there is a prominent alternative approach, which was developed by Stock and Watson (2012) and Mertens and Ravn (2013). Here, narrative measures are used as instrumental variables only, and not directly as the shocks of interest. An advantage of their approach is that the structural coefficients can be identified. However, estimating Specification (1.1) has the advantage that – in the language of the program evaluation literature – the average treatment effect is correctly identified, whereas an instrumental variables estimation only delivers the local average treatment effect. This is a problem if there is heterogeneity in the treatment effects, see Stock and Watson (2008). Given the host of tax instruments, heterogeneous treatment effects are likely. We therefore conclude that for our purposes, the estimation of the reduced form is more suitable.[10]

Next, we will briefly comment on our selection of p and s, the number of lags for the endogenous and for the exogenous variables respectively.

Determination of p and s. The lag length p determines the dynamics of the endogenous variables. We set $p = 3$, as suggested by the Akaike information criterion. Our results are robust to a longer lag structure.

The number of lags of the exogenous variable s determines the number of periods during which a narrative tax shock Δtax_t affects the system of endogenous variables. Ideally, we would like to estimate an infinitely distributed lag model to measure the impact of exogenous tax shocks, see e.g. Romer and Romer (2010) and Cloyne (2013). That is, we would like to set s to a very large number. However, there is a trade-off between a long lag structure and saving degrees of freedom, in particular in small samples. Following Romer and Romer (2010), many authors have set $s = 12$, see e.g. Mertens and Ravn (2011, 2012) and Cloyne (2013). In contrast to us, these authors do not incorporate the average

[10] Another issue with the instrumental variable approach is that tax narratives have been shown to be weak instruments, see e.g. Hebous and Zimmermann (2015) and Ramey (2015). Ramey (2015) argues that weak instruments lead to a downward bias, implying that the 'true' tax multipliers might be even larger. The impact of weak instruments in empirical macroeconomics more generally are analyzed by Montiel Olea, Stock, and Watson (2012) and by Hebous and Zimmermann (2015).

tax rate (i.e. tax revenues/GDP) as an endogenous variable. This is done by Favero and Giavazzi (2012), who set $s = 0$, i.e. they only consider contemporaneous values of Δtax_t.

We depart from Favero and Giavazzi (2012) and set $s = 1$, for the following reason. The narrative record of Δtax_t measures changes in tax liabilities, whereas in the data, we observe changes in tax revenues. We would expect that, for administrative reasons, it takes time before a tax liability change shows up as a change in tax revenues. This time lag is captured by s, among other things.

In Figure 1.A.2, we compare the impulse responses of tax revenues/GDP for $s = 0$ and $s = 1$. For $s = 0$, we observe only a small initial response of tax revenues/GDP to an exogenous increase in tax liabilities by one percent of GDP. If we set $s = 1$, the response becomes hump-shaped with a peak in the first quarter following the tax increase. Since the response at the peak is much larger than on impact, this suggests that there is a time lag of one quarter until the increase in tax liabilities translates into higher tax revenues. This is in line with Perotti (2012), who also argues that it takes time until tax revenues react after a tax change.

The shape of the impulse response of tax revenues/GDP remains constant for all $s \geq 1$. We therefore use $s = 1$ in our estimation procedure. We would like to stress that all our results are also robust to a longer lag structure for Δtax_t.

Correcting for measurement error. As Figure 1.A.2 makes evident, a narrative shock Δtax_t that increases tax liabilites by one percent of GDP does not change tax revenues/GDP one-to-one. Without further corrections, our results would therefore be subject to an attenuation bias.[11] Stock and Watson (2012), Mertens and Ravn (2013), and most recently Hebous and Zimmermann (2015) all argue that narrative series are likely to suffer from severe measurement problems.[12]

Our procedure to correct for the resulting bias is inspired by Stock and Watson (2012) and by Mertens and Ravn (2013). More precisely, we normalize the narrative tax liability changes such that a one unit positive shock (i.e an increase in tax liabilities by one percent of GDP) increases tax revenues/GDP by one percent at the peak.[13]

[11] Mertens and Ravn (2013) discuss several reasons why narrative shocks could be misreported. Narrative measures may for example be censored because large innovations are more likely to be measured. In addition, the narrative record may misreport exogenous, unanticipated tax changes as either endogenous or anticipated. Measurement error could also occur because the size of the innovations Δtax_t is mismeasured, e.g. because of wrong scaling. Δtax_t is computed using available projections of changes in tax liabilities. These projections assume that the tax base remains constant following a tax change. Clearly, this is not the case, since GDP, and therefore the tax base, decline following a tax increase.

[12] Interestingly, Hebous and Zimmermann (2015) show that there is a close connection between what we call 'measurement problems' and the fact that narratives tend to be weak instruments, as outlined in Footnote 10.

[13] Stock and Watson (2012) and Mertens and Ravn (2013) normalize tax shocks according to the response of the endogenous variable on impact. Due to the difference between tax liabilities and tax

In the following, we will refer to the specification described above as our baseline VAR. The effects of a positive tax shock on the endogenous variables are standard and confirm the findings from the previous literature using the Romer and Romer (2010) narrative identification. The impulse responses are presented in Figure 1.A.3.[14]

1.4 The Impact of Tax Changes on Excess Bond Premia

In this section, we demonstrate that tax liability changes have an impact on excess bond premia.

Technically, we proceed as follows. We use Specification (1.1) and augment it by either EBP or FBP. The results are shown Figure 1.A.4. A rise in tax liabilities by one percent of GDP increases excess bond premia by between 0.8 and 1.8 percentage points, depending on whether we consider FBP or EBP. Apart from the difference in the level, which may be due to the fact that the time series of the two excess bond premia do not have the same length, the shape of the responses for EBP and FBP is almost identical.

In this paper, we focus on excess bond premia. However, we would have also found a significant response had we used other, more conventional corporate bond spreads, such as the spread between yields of Aaa-rated corporate bonds and Treasuries or the spread between BAA-rated corporate bonds and Treasuries. See also Ji and Qian (2015), who document an impact of tax liability changes on bank spreads.

So far, we have documented that tax changes affect excess bond premia for both non-financial and financial firms. In the remainder of this paper, we want to understand why taxes have an impact on these spreads. For this purpose, we will first identify the determinants of excess bond premia in theory. Specifically, we will document that balance sheet conditions of financial intermediaries are important drivers of excess bond premia. In a second step, we will then show that tax changes that drive excess bond premia also affect intermediaries' balance sheet conditions empirically.

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revenues and the associated time lag discussed above, we argue that our normalization procedure leads to a better assessment of the bias. Normalizing according to the response of tax revenues/GDP on impact would result in even larger multipliers. More precisely, we normalize by multiplying all elements of $D(L)$ by $\frac{1}{b_1^{tr}}$, where b_1^{tr} is the coefficient of B_1 that is estimated in the equation for tax revenues/GDP one quarter after the tax shock hits. Here, we implicitly assume that tax revenues/GDP peak in the quarter after the tax shock occurred, in line with our empirical results displayed in Figure 1.A.2.

[14] We use asymptotic standard errors with a small-sample correction. Bootstrapping standard errors with 10'000 replications as in Mertens and Ravn (2011) leads to identical results.

1.5 Financial Frictions, Financial Intermediaries, and Corporate Bond Spreads: Evidence from Theory

In this section, we explore the theoretical determinants of excess bond premia. We start our analysis by looking at their precise meaning. By construction, the excess bond premium measures the component of corporate bond spreads that cannot be explained by the default risk of the borrower, see Gilchrist and Zakrajsek (2011, 2012). In other words, the excess bond premium measures the risk premium that the investor requires for holding corporate bonds (see Adrian, Moench, and Shin 2010 for more empirical evidence on the relationship between the risk premium and excess bond premia). Therefore, our finding that tax changes affect excess bond premia implies that taxes also have an effect on the willingness of investors to accept the risk associated with corporate bonds. This begs the question of who invests in corporate bonds.

The importance of financial intermediaries for understanding corporate bond prices. Recent research suggests that corporate bonds are priced by financial intermediaries. There is a large empirical literature that studies the level and the variations of corporate bond spreads, concluding that spreads appear to be too high to be explained by a household pricing kernel (see e.g. Collin-Dufresne, Goldstein, and Martin 2001). Consequently, He and Krishnamurthy (2013) and Brunnermeier and Sannikov (2014), among others, assume that corporate bonds are priced by financial intermediaries.[15] Other models of financial intermediation also assume that savers, or households, cannot buy assets directly, see e.g. Gertler and Kiyotaki (2010).

With respect to corporate bonds, the assumption that they are almost exclusively held by financial intermediaries is also borne out by the data. According to the 2012 Flow of Funds, the personal sector only owned 2326 billion US dollars (USD) of corporate or foreign bonds (see Table L.10), compared to 7579 billion USD that were held by financial intermediaries (see Table L.107).[16] The picture looks very different for stocks (i.e. corporate equity). Here, the personal sector directly owned 9771 billion USD, whereas financial firms held 12514 billion USD in corporate equity. In sum, this suggests that the fraction of risky assets in the hand of households depends on the asset type.

Based on these findings, we assume that households do not matter for the pricing of corporate bonds, but that they have an impact on the price of stocks. While this distinction does not matter for our analysis in this section, it will become important later,

[15] See also Xiong (2001). Brunnermeier, Eisenbach, and Sannikov (2012) survey the literature.

[16] The personal sector consists of households, non-profit organizations and non-financial, non-corporate businesses.

when we argue that changes in personal income taxes, in particular in dividend/capital gain taxes, affect stock prices. Obviously, personal income tax adjustments can affect equity valuations only if the personal sector directly owns corporate equity.[17]

The link between excess bond premia and financial intermediaries' balance sheet conditions. A common feature of models in which financial intermediaries price assets is that their willingness to hold (risky) assets is linked to their net worth position. This link typically arises because there is an agency problem between intermediaries and households, who are the ultimate suppliers of funds. While the specific details differ across models, a common assumption that is shared by many of them is that there is moral hazard by the intermediary, as in Holmstrom and Tirole (1997). As a result, households require that the intermediary has a sufficient stake in the business in order to prevent shirking.

Suppose now that intermediaries' net worth is subject to a negative shock. Then, the incentive compatibility constraint, which prevents intermediaries from shirking, becomes binding. A binding incentive compatibility constraint might then imply, as in He and Krishnamurthy (2013), that intermediaries (or 'specialists') have to hold more risky assets, since they are the only ones who can directly acquire them. In He and Krishnamurthy (2013), specialists are risk-averse. As a consequence, they are only willing to hold a larger share of risky assets if they get compensated in the form of a higher risk premium.

Using a different approach, Brunnermeier and Sannikov (2014) instead generate variations in the risk premium without assuming risk-aversion on the side of specialists. In their model, specialists display risk-averse behavior in the aggregate because their investment opportunities negatively comove with their wealth.

Evidence in support of these theories is provided by Adrian, Moench, and Shin (2010), Adrian and Shin (2010a), Adrian and Shin (2010b), and Adrian, Colla, and Shin (2012), who show that financial intermediaries' balance sheet conditions are important for their effective risk-bearing capacities and therefore also for asset prices in general.

In sum, this strand of literature suggests that shocks to intermediaries' net worth are an important determinant of observed variations in the excess bond premium. Indeed, we will later document that those tax events that are key for explaining the response of excess bond premia also affect the health of intermediaries' balance sheets.

As a measure of financial intermediaries' balance sheet conditions, we will use their return on assets. Our choice is in part motivated by Gilchrist and Zakrajsek (2012) who document a negative correlation between the return on assets of financial firms and EBP, the excess bond premium of corporate bonds issued by non-financial firms. If intermediaries' balance sheet conditions are important for explaining the link between

[17] As we will argue later, there is ample empirical evidence for the fact that dividend/capital gain tax adjustments indeed have an impact on equity valuations.

tax adjustments and excess bond premia, we should therefore observe that the same tax changes that affect excess bond premia also have an impact on the return on assets. In the next section, we will show that this is indeed the case.

Before we analyze the relationship between tax changes, excess bond premia and intermediaries' balance sheet conditions in greater detail, we will discuss a few alternative explanations for the link between tax adjustments and risk premia.

Alternative explanations for the link between tax changes and corporate bond spreads. In addition to the balance sheet channel mentioned above, there might be alternative explanations for the link between tax liability changes and excess bond premia. One possibility is that variations in taxes alter the total amount of public debt held by the private sector. Krishnamurthy and Vissing-Jorgensen (2012) show that lower public debt/GDP ratios are associated with higher corporate bond spreads, a finding that they attribute to the special role that government bonds play as a liquid and safe asset. As we will explain later, the response of excess bond premia is driven by only a few tax events. We have conducted tests to check whether any of these tax acts leads to a significant response in public debt held by private households, as a fraction of GDP. Our preliminary findings suggest that this is not the case.[18]

It could of course be that corporate bond spreads change because there are other sources that affect the supply of safe and liquid assets (i.e. changes in the supply of money, as mentioned by Nagel 2014). Alternatively, it is also possible that there are changes in the demand for safe and risky assets (i.e. an increase in uncertainty). However, note that factors that influence corporate bond spreads would have to comove with tax changes in order to account for the relationship between taxes and excess bond premia that we documented above. A priori, it is not clear why this should be the case.

We therefore conclude that there might be alternative ways through which tax changes could potentially affect excess bond premia, other than through intermediaries' balance sheet conditions. We leave it to future research to disentangle the quantitative importance of the various channels. Our contribution is to document that financial intermediaries' balance sheets respond to the same tax events that also drive the response of excess bond premia, a finding that is independent of the potential coexistence of other channels.

[18] Our results are independent of whether we incorporate public debt/GDP or the log of real public debt in per-capita terms, divided by the GDP deflator. Moreover, our findings are also robust to measuring public debt at face value or at market prices.

1.6 The Impact of Tax Changes on Financial Frictions, Financial Intermediaries, and Excess Bond Premia: Empirical Evidence

In this section, we empirically analyze the link between tax changes and corporate bond spreads in greater detail. In line with the theoretical arguments from the previous section, we document that those tax acts that affect corporate bond spreads also have an impact on balance sheet conditions of financial intermediaries.

Moreover, our findings allow us to pinpoint exactly through which channel tax changes affect balance sheet conditions of financial intermediaries. Given that there are many determinants that influence balance sheets of the financial sector, our previous assumption that all tax changes are identical with respect to the size of their effects and that their dynamics can be estimated using the same system appears to be overly restrictive. In the following, we will therefore relax this assumption and allow for heterogeneity across tax changes.

Overview. Technically, we proceed as follows. In a first step, we distinguish between the two most important subgroups of tax changes, personal and corporate income tax adjustments. Together, both groups account for 75 percent of total federal tax revenues (Mertens and Ravn 2013). We estimate a separate VAR for personal and corporate income tax changes, thereby allowing for different dynamic responses to an adjustment of taxes in one of the two groups.

Within each group, tax changes differ substantially with respect to their size, see Figure 1.A.5. In a second step, we therefore investigate to what extent specific tax changes influence the aggregate impact of personal and corporate tax changes that we identified in the first step. We do so by introducing dummy variables for the most important tax acts in our sample. These tax acts are the 1986 Tax Reform Act (TRA), the 1987 Omnibus Tax Reconciliation Act (OBRA), the 1990 Omnibus Tax Reconciliation Act (OBRA), and the 2003 Jobs and Growth Tax Relief Reconciliation Act (JGTRRA). All of these tax changes belong to the post-1984 period, for which we have information on the excess bond premia of both financial and non-financial firms. In this second step, we follow the 'dummy variable approach' employed by Ramey and Shapiro (1998) and in particular by Burnside, Eichenbaum, and Fisher (2004), who allow for different intensities of important military buildups in the US in order to estimate the government expenditure multiplier.

Measuring the impact of personal and corporate tax changes. Using the Romer and Romer (2010) data as a source, Mertens and Ravn (2013) construct separate time series of exogenous, unanticipated tax changes for corporate income taxes and personal income taxes. Corporate income tax changes include adjustments in depreciation allowances, investment tax credits and marginal tax changes. Personal income tax changes include marginal income tax adjustments, adjustments in capital gain and dividend taxes, and various deductions and tax credits. In order to distinguish between the impact of personal and corporate income tax changes, we apply the Mertens and Ravn (2013) methodology to our data. The resulting categorization of every single tax change is given in Table 1.A.2 in the Appendix.

Similar to our baseline specification, we estimate the following VAR:

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=0}^{s} B_j x_{t-j} + D + Et + u_t \tag{1.2}$$

where x_t is now given by either Δtax_t^{PI} or Δtax_t^{CI}, depending on whether we are interested in estimating the impact of an adjustment in personal income taxes (PI) or corporate income taxes (CI). As before, we also include a constant D and a linear time trend with coefficient matrix E in the exogenous part of the VAR. We modify the vector y_t of endogenous variables by replacing the variable tax revenues/GDP with the average personal income tax rate (APITR) and the average corporate income tax rate (ACITR). We follow Mertens and Ravn (2013) and define:

$$\text{APITR}_t = \frac{\text{Personal Current Taxes}_t + \text{Contributions to Govt. Social Insurance}_t}{\text{Personal Taxable Income}_t}$$

$$\text{ACITR}_t = \frac{\text{Taxes on Corporate Profits}_t}{\text{Corporate Profits}_t}$$

Identification and bias correction of the impulse responses. Again, we set the number of endogenous lags to $p = 3$ and the lag length of exogenous variables to $s = 1$. All our following results are robust to including more lags.

It is important to note that Δtax_t^{PI} and Δtax_t^{CI} are positively correlated, since, for most tax events, Δtax_t^{PI} and Δtax_t^{CI} are changed in the same direction.

This correlation may give rise to an omitted variable bias if we incorporate only Δtax_t^{PI} or Δtax_t^{CI} in Specification (1.2).

Fortunately, we are able to assess the strength of the omitted variable bias by analyzing the cross-responses, i.e. the response of APITR (ACITR) in Specification (1.2) to Δtax_t^{CI}

(Δtax_t^{PI}). If the cross-responses are insignificant, then the impact of the omitted variable is limited.

The results are shown in Figure 1.A.6. The left panel displays the response of APITR to Δtax_t^{CI}. Although it increases, it is not significantly different from zero. The same is true if we consider the response of ACITR to Δtax_t^{PI}, shown in the right panel of Figure 1.A.6. Given that all cross-responses are insignificant, we conclude that the omitted variable problem should not bias our results significantly. This test is inspired by Mertens and Ravn (2013), who separate the impact of corporate and personal income tax changes by assuming that a change in Δtax_t^{PI} affects only APTIR on impact, but not ACITR, and vice versa.[19]

In order to further alleviate potential concerns regarding the presence of an omitted variable bias, we will include *both* Δtax_t^{PI} and Δtax_t^{CI} into Specification (1.2) in a robustness check. All of our results survive this test. Hence, we conclude that our results are not biased because we omit either personal or corporate income tax changes. Note that when we incorporate both Δtax_t^{PI} and Δtax_t^{CI}, we also implicitly assume that the coefficients of the A matrix, which govern the dynamics of the endogenous variables, are identical for both personal and corporate income tax changes. This is also the case in Mertens and Ravn (2013), who estimate the dynamic effects of personal and corporate income tax changes within the same VAR.

Finally, we correct for the measurement error inherent in the narrative measures for Δtax_t^{CI} and Δtax_t^{PI} by rescaling our impulse responses such that ACITR (respectively APITR) increases by one percent at the peak.

1.6.1 Personal Income Taxes and Corporate Bond Spreads

Figure 1.A.7 summarizes the responses of EBP and FBP to an adjustment in personal income taxes. Personal income tax changes drive up both excess bond premia. In particular the response of EBP is sizeable and highly significant, whereas the response of FBP is insignificant using a 95 percent confidence interval. This may be due to the fact that there is a small number of degrees of freedom, given that FBP is not available before 1985.[20]

The fact that personal income tax changes have an impact on corporate bond spreads implies that the overall link between tax changes and corporate bond spreads is not only due to the impact of corporate income tax changes on firms' leverage decisions, as suggested by many important theories in corporate finance, such as e.g. the trade-off

[19]Note that this specification tests the recursivity assumption employed by Mertens and Ravn (2013) to separate the impact of personal and corporate income tax liability changes.

[20]Indeed, if we reduce the number of lags, the confidence interval becomes substantially smaller.

theory.[21] See Tirole (2006) for an intuitive overview of the static theory and Strebulaev and Whited (2011) for the dynamic version.

How do personal income tax changes affect corporate bond spreads? We argue that personal income tax changes affect corporate bond spreads via balance sheet conditions of financial intermediaries. Specifically, taxes have an impact on stock prices, which are an important part of banks' balance sheets. Our argument is structured as follows. First, we show that personal income tax changes have an impact on stock market returns, a finding that is consistent with the tax capitalization hypothesis, according to which an unexpected change in the taxation of income from dividends and capital gains affects stock prices and therefore stock returns (see e.g. Sialm 2009 for recent evidence).

In order to explain the transmission of tax changes to corporate bond spreads, we refer to theories according to which corporate bonds are priced by financial intermediaries. We have in mind models such as e.g. Holmstrom and Tirole (1997) and He and Krishnamurthy (2013). In these models, shocks to financial intermediaries' balance sheets translate into changes in corporate bond spreads.

Based on this argument, we conclude that personal income tax events affect balance sheet conditions of financial intermediaries through changes in stock prices and stock returns. Stocks account for a sizeable fraction of financial intermediaries' assets. A change in stock returns therefore affects the return on assets of financial intermediaries, thereby altering the willingness of the financial sector to hold corporate bonds.

We test our hypothesis by incorporating a dummy for the 2003 JGTRRA into our VAR. According to Sialm (2009), the 2003 JGTRRA had the largest impact on effective tax rates for dividends and capital gains. Excluding this tax act from our sample should therefore attenuate the responses of stock market returns. If our hypothesis is true, we should also see that the return on assets of financial intermediaries only responds to the 2003 JGTRRA, but not to other tax events. Finally, corporate bond spreads should also change only if we consider the 2003 JGTRRA. We show that all of these effects are indeed borne out by the data. In sum, we interpret our findings as strong evidence for the fact that personal income tax changes affect corporate bond spreads via stock market returns and their impact on the profitability of the financial sector. The 2003 JGTRRA is key for explaining the overall impact of personal income tax changes.

Personal income tax changes and stock market returns. We start by analyzing the general relationship between stock market returns and personal income tax changes.

[21] According to the trade-off theory, corporate income tax changes are the main determinant of the equity-debt trade-off because debt payments are exempted from corporate income taxation, whereas equity payments are not. Firms then face a trade-off between reducing tax payments and increasing debt, which also increases expected default.

In the first panel of Figure 1.A.8, we plot the impulse response of the excess stock market return to an increase in personal income taxes by one percentage point. The excess stock market return is defined as the (value-weighted) stock market return (including dividends) of the New York Stock Exchange minus the return on short-run (3 months) T-Bills.

After an increase in personal income taxes by one percent relative to the tax base, the excess stock market return falls by more than 30 percentage points on impact, and starts rising immediately afterwards back to its pre-tax level. The sharp drop in the excess stock market return is driven by a decline in equity valuations, as indicated by the response of the price/dividend ratio and the cyclically adjusted price/earnings ratio, which decrease by five and two percentage points respectively.[22]

The response of stock prices is consistent with the predictions of the 'tax capitalization hypothesis' (see e.g. Sialm 2009) for an unexpected increase in dividend/capital gain taxation. According to this hypothesis, stock prices immediately drop after an unexpected increase in dividend/capital gain taxation, even if dividends are not affected. This is because investors are willing to pay less for stocks, so that their after-tax return is unaffected by the tax increase. Additional evidence for the importance of dividend taxes for stock prices is presented by McGrattan and Prescott (2005), who argue that the fall in the average marginal dividend tax rate between 1960 and 2000 can account for the increase in equity prices during the same period.

In the following, we show that the response of stock markets to personal income tax adjustments is mainly driven by the 2003 JGTRRA. We argue that this finding is perfectly consistent with the tax capitalization hypothesis, since the 2003 JGTRRA constituted the largest change for capital gains and dividend taxes in the post-1970 sample of tax events. We begin by briefly summarizing the dividend and capital gain tax changes introduced by the 2003 JGTRRA.

The 2003 JGTRRA. Calculations made by Sialm (2009) (see Figure 1 in his paper) reveal that the 2003 JGTRRA had a massive impact on dividend tax rates. Among other measures, the 2003 JGTRRA reduced the dividend tax rate for qualified dividends, relative to the ordinary income tax rate. The effective reduction was substantial for all income brackets, including the top. For households in the highest income bracket, the marginal tax on dividend income fell from almost 40 to 15 percent. This decline is substantial, compared to other tax acts.[23] In addition to dividend taxes, the 2003

[22]Data on the price/dividend ratio and the cyclically adjusted price/earnings ratio are available on Robert Shiller's webpage: `http://www.econ.yale.edu/~shiller/data/ie_data.xls`, retrieved on May 19, 2015.

[23]Notable examples of other tax acts that affected only individual income tax rates in the post-1970 period, which is the time span that we are focusing on in this section, are the Economic Recovery Tax Act (ERTA) of 1981 and the TRA of 1986. However, the calculations in Sialm (2009) show that both

JGTRRA also reduced the marginal tax rate on capital gains from 20 to 15 percent.

The quantitative importance of the 2003 JGTRRA is also visible from Figure 1.A.5, where we plot the narrative measure for Δtax^{PI} along with Δtax^{CI}. With a decrease in personal income tax liabilities of more than one percent relative to the personal income tax base, the 2003 JGTRRA is by far the largest personal income tax change in the post-1970 period. In the following, we analyze the implications of the 2003 JGTRRA for stock prices in greater detail.

The importance of the 2003 JGTRRA for stock markets. In order to analyze the importance of the 2003 JGTRRA for the response of stock market returns, we isolate the 2003 JGTRRA from the rest of the post-1970 personal income tax changes considered by the Mertens and Ravn (2013) narrative. More specifically, we estimate the following system:

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=0}^{s} B_j^o \Delta\text{tax}_{t-j}^{PI,o} + \sum_{j=0}^{s} B_j^J \Delta\text{tax}_{t-j}^{PI,J} + D + Et + u_t \tag{1.3}$$

where $\Delta\text{tax}^{PI,o}$ denotes all unanticipated personal income tax changes other than the 2003 JGTRRA and $\Delta\text{tax}^{PI,J}$ denotes the 2003 JGTRRA. We are interested in $D^{PI,o}(L) := A(L)^{-1}B^o(L)$, the dynamic multiplier associated with $\Delta\text{tax}^{PI,o}$. We again include a constant and a linear time trend in the deterministic part of the VAR.

We would like to stress that when estimating Specification (1.3), we are only interested in the sign and the significance of the multipliers, but not in their magnitude.[24] Our specification is thus similar to the dummy variable approach used in Ramey and Shapiro (1998) and Burnside, Eichenbaum, and Fisher (2004). When interpreting the sign of the estimated dynamic multipliers, it is important to keep in mind that we compute the effect of an increase in personal income tax liabilities, even if we consider the impact of the 2003 JGTRRA alone, which actually constituted a reduction in tax liabilities. We do this in order to be consistent with the rest of our analysis. Due to the linearity of the VAR, this only has an effect on the sign of the dynamic multipliers, but not on their magnitude.

To estimate the dynamic multiplier for the price/dividend ratio, for the cyclically adjusted price/earnings ratio and for the excess stock market return, we add each of these

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tax acts only have a small negative impact on the marginal dividend tax rate, compared to the 2003 JGTRRA. With respect to the marginal tax rate on long-run capital gains, Sialm (2009) reports a small negative effect for the 1981 ERTA only. The 1986 TRA even increased the marginal tax rate on long-run capital gains. This is because the 1986 TRA broadened the capital income tax base considerably, thereby repealing many opportunities to deduct taxes. Auerbach and Slemrod (1997) provide a complete description of the 1986 TRA.

[24] This is because $\Delta\text{tax}^{PI,o}$ and $\Delta\text{tax}^{PI,J}$ are potentially subject to different measurement error, rendering a direct comparison of the estimated dynamic multipliers $D^{PI,o}(L)$ and $D^{PI,J}(L)$ meaningless anyway.

time series to our system separately as an additional endogenous variable. The results for $\Delta\text{tax}^{PI,o}$ are shown in Figure 1.A.9.

As a comparison of Figures 1.A.8 and 1.A.9 makes evident, excluding the 2003 JGTRRA (i.e. considering the response of $\Delta\text{tax}^{PI,o}$) renders the response of the price/dividend ratio zero, while the response of both the price/earnings ratio and the excess stock market return become insignificant. We therefore conclude that the 2003 JGTRRA is pivotal in explaining the responses of equity valuations and equity returns to personal income tax changes. This confirms that dividend/capital gain taxes drive stock returns.

The impact of the 2003 JGTRRA on balance sheet conditions of financial intermediaries. We now turn to the relationship between personal income tax changes and balance sheet conditions of financial intermediaries. Our analysis is motivated by the fact that corporate equity holdings account for a sizeable fraction of total assets of financial intermediaries.[25] Given that personal income tax changes affect stock returns, we therefore expect that they also affect the return on assets of the financial sector. In particular, our previous analysis has shown that the relationship between personal income tax changes and stock returns is mainly driven by the 2003 JGTRRA. According to our hypothesis, the same should be true for the return on assets of financial intermediaries.

In order to test this hypothesis, we use Specification (1.3) and include the following variables into y, the vector of endogenous variables: the return on assets for all financial firms (see Gilchrist and Zakrajsek 2012), the return on assets for commercial banks, which are the largest subgroup of the financial sector, as well as the excess stock market return, as defined above.[26]

In order to save degrees of freedom, we drop all other endogenous variables from our baseline system, with the exception of APITR and ACITR. For this new system, we pick $s = 6$ for the number of lags for the endogenous variables, based on likelihood ratio tests. With respect to the number of exogenous lags, we keep $p = 1$, as before.

As Figure 1.A.10 shows, the return on assets for the overall financial sector responds significantly if we consider the 2003 JGTRRA (left panel), whereas we cannot observe any reaction for all other personal income tax changes (right panel). This result thus confirms our hypothesis that personal income tax changes affect balance sheet conditions through stock market returns. We find that the response of the return on assets of commercial banks is identical to the response of the return on assets of the overall financial sector. The corresponding figure is therefore omitted.

[25] According to the US Financial Accounts (see Table L.107), holdings of corporate equity account for almost 20 percent of the asset positions of financial business in the US and are therefore the second largest asset position, after credit instruments, which constitute the core business of the financial sector.

[26] The return on assets for commercial banks is calculated using Compustat data.

Our analysis is partly motivated by the high explanatory power of the return on assets of the financial sector for the excess bond premia. The return on assets of all financial firms alone can explain between 35 percent and 45 percent of the total variation, depending on whether we consider the excess bond premium for non-financial or for financial firms.[27] Gilchrist and Zakrajsek (2012) also find that there is a tight link between the excess bond premium of non-financial firms and the return on assets of financial firms.

This suggests that balance sheet conditions of financial intermediaries are important determinants of excess bond premia. We will test this more formally in the next paragraph.

The link between the 2003 JGTRRA and corporate bond spreads. We now return to the relationship between personal income tax events and corporate bond spreads that we documented earlier. If corporate bonds are indeed priced by financial intermediaries, as suggested by the institutional finance literature reviewed previously, the impact of personal income tax changes on corporate bond spreads should hinge on the 2003 JGTRRA, since, as shown above, only the 2003 JGTRRA leads to a response of the return on assets of financial intermediaries.

In this section, we use Specification (1.3) to test to what extent the response of corporate bond spreads, in particular EBP, is indeed driven by the 2003 JGTRRA. As the results in Figure 1.A.11 indicate, excluding the 2003 JGTRRA renders the response of EBP insignificant. In contrast, the response to $\Delta\text{tax}^{PI,J}$, which measures the impact of the 2003 JGTRRA, is remarkably similar (in terms of shape) to the overall response generated by all personal income tax changes Δtax^{PI} that we documented earlier using Specification (1.2). Of course, the level differs markedly, given that the impulse responses in Figure 1.A.11 are not scaled. Note that we do not consider FBP, since as demonstrated above, its response to personal income tax changes is insignificant anyway.

Our finding that the 2003 JGTRRA is pivotal for the response of corporate bond spreads and aggregate stock market returns relates our work to the seminal paper by Collin-Dufresne, Goldstein, and Martin (2001). Collin-Dufresne, Goldstein, and Martin (2001) find that aggregate stock market returns are a powerful determinant of corporate bond spread changes. Interestingly, they show that aggregate returns outperform individual firms' stock returns as determinants of corporate bond spreads by far. Their result is at odds with the predictions from standard theory (consider for example the famous Merton 1974 model), according to which corporate bond spreads are related to individual but not to aggregate stock returns.[28]

[27] These values refer to the R^2 of a regression of EBP (FBP) on the return on assets.

[28] This is unless aggregate stock returns are a proxy for the expected recovery rate after default. There is little empirical evidence for this, see Collin-Dufresne, Goldstein, and Martin (2001).

The failure of standard asset pricing models to explain corporate bond spreads motivates the institutional finance literature to consider the balance sheet conditions of financial intermediaries, see e.g. He and Krishnamurthy (2013).[29] By showing that there is a link between personal income tax changes on the one hand and balance sheet conditions of financial intermediaries and corporate bond spreads on the other hand, we provide further empirical support for the importance of financial intermediaries for corporate bond pricing.

Our findings are also related to a large literature studying the impact of the 2003 JGTRRA on equity valuations and corporate behavior in general, see e.g. the work by Poterba (2004), Auerbach and Hassett (2005, 2006), Chetty and Saez (2006), Brown, Liang, and Weisbenner (2007), Amromin, Harrison, and Sharpe (2008), Anagnostopoulos, Cárceles-Poveda, and Lin (2012), and most recently Yagan (2015).

We contribute to this strand of literature by documenting a novel link between the 2003 JGTRRA and equity valuations on the one hand and balance sheet conditions of financial intermediaries and corporate bond spreads on the other hand. This link implies that the 2003 JGTRRA also had an impact on the cost of debt financing of firms, via the balance sheet conditions of financial intermediaries.

Discussion: other evidence for the impact of the 2003 JGTRRA on equity valuations. Our argument hinges on the finding that the 2003 JGTRRA had a positive impact on equity valuations. In the following, we will carefully scrutinize this result. A visual inspection of the time series of the S&P 500 stock market index indeed suggests that share prices rose around the announcement date of the 2003 JGTRRA, see Figure 1 in Amromin, Harrison, and Sharpe (2008). What is further needed in order to argue that this rise is at least partly due to 2003 JGTRRA is that the announcement of the tax act was unanticipated. According to Brown, Liang, and Weisbenner (2007), the tax change moved particularly fast from its first proposal in January 2003 to the signed law in May 2003. In addition, Auerbach and Hassett (2005) mention that the political debate was unpredictable, which created a lot of uncertainty among market participants. Amromin, Harrison, and Sharpe (2008) provide evidence that prior to mid-May 2003, it was still unclear whether any substantial cut in dividend taxes would find a majority.

However, the unexpected announcement of the 2003 JGTRRA is not sufficient to prove an impact of the 2003 JGTRRA on equity valuations, since there might have been other events that also influenced stock prices. For example, Amromin, Harrison, and Sharpe (2008) mention investors' relief about the resolution regarding the military intervention in Iraq as a potential confounding event that occurred over the same period.

[29]Indeed, He and Krishnamurthy (2013) refer to Collin-Dufresne, Goldstein, and Martin (2001), see their Footnote 1.

It is not possible for us to control for other factors that occurred at the same time, for example by including a time dummy, since this dummy would be perfectly collinear with $\Delta \text{tax}^{PI,J}$. However, recall that the 2003 JGTRRA brought about a massive change in dividend taxation. Therefore, anything other than a major impact of the 2003 JGTRRA on share prices would be difficult to reconcile with the findings of Sialm (2009), who documents that dividend/capital gain tax changes have a significant effect on stock market valuations. The results by Sialm (2009) are based on time series evidence from 1913 to 2006 and on evidence from cross-sectional data. In addition, we would like to stress that there are many other papers that present direct evidence for the impact of the 2003 JGTRRA on individual stock prices. Examples include Auerbach and Hassett (2005) and Brown, Liang, and Weisbenner (2007) who both use firm level data. We therefore conclude that there is strong evidence for the impact of the 2003 JGTRRA on equity valuations.

1.6.2 Corporate Income Taxes and Corporate Bond Spreads

In this section, we document that corporate income tax changes have an impact on corporate bond spreads. Specifically, we show that an increase in corporate income taxes raises EBP and FBP.

In a second step, we analyze whether balance sheet conditions of financial intermediaries are also affected by corporate income tax changes. Indeed, this appears to be the case. An increase in corporate income taxes adversely affects the return on assets of commercial banks and of the financial sector in general; a finding that is in line with our results for personal income tax changes.

However, in contrast to our previous findings, stock market returns do not seem to matter for the transmission of corporate income tax changes to balance sheet conditions of financial firms. Instead, our results suggest that the return on assets declines because banks increase their loan loss provisions. We document that the rise in loan loss provisions occurs in parallel with the increase in the fraction of non-performing commercial and industrial (C&I) loans, which suggests that the increase in the latter is the reason for the rise in the former.

We then turn to the question why corporate income tax changes affect the fraction of non-performing C&I loans. To find the answer, we check which tax event (or which group of tax events) from our narrative record is able to explain the response in the fraction of non-performing loans, loan loss provisions, and the return on assets simultaneously. We expect that the response of corporate bond spreads to changes in corporate income taxes also hinges on this tax shock (or this group of tax shocks) if the banks' balance sheet conditions indeed matter for the transmission of tax changes to corporate bond spreads.

Our analysis reveals that the 1986 TRA is the sole driver for the response of non-performing loans and loan loss provisions. We further show that the 1986 TRA also has an impact on the return on assets of financial intermediaries and on FBP, but not on EBP.

Finally, we analyze how the 1986 TRA could have triggered an increase in the fraction of non-performing loans. One of the main objectives of the 1986 TRA was to 'level the playing field', see Poterba (1992). This required a broadening of the tax base by reducing investment in tax shelters and by abolishing deductions. Losers of the reform were therefore firms in capital-intensive sectors such as mining and heavy industries (see Cutler 1988).

The impact of corporate income tax changes on corporate bond spreads: aggregate evidence. Paralleling our approach for personal income tax changes, we estimate the following VAR:

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=0}^{s} B_j \Delta \text{tax}_{t-j}^{CI} + D + Et + u_t \tag{1.4}$$

The vector of endogenous variables y consists of our baseline variables (including APITR and ACITR). Again, we include a constant D and a deterministic time trend with coefficients E. We set $p = 3$ and $s = 1$, as before. Our results are robust to higher lag orders. As we will show later, most of our results are also robust to additionally controlling for Δtax^{PI}.

The responses to a one percentage point increase in ACITR are depicted in Figure 1.A.12. EBP and FBP increase by around 0.3 and 0.4 percentage points respectively. Different from personal income tax changes, the response of FBP now appears to be more sizeable.

The impact of corporate income tax changes on balance sheet conditions of the financial sector. We now analyze whether corporate income tax changes affect balance sheet conditions in the financial sector. According to the theoretical literature presented above, this would explain the increase in the excess bond premia that we just reported.

We incorporate either the return on assets for the overall financial sector or the (pre-tax) return on assets for commercial banks, which is the largest subgroup within the financial sector, into Specification (1.4). Our results are identical for the return on assets of the total financial sector and of commercial banks. In the following, we will therefore focus on the return on assets for commercial banks. We do so because balance sheet conditions of commercial banks will play a decisive role in the remainder of our analysis.

As Figure 1.A.13 reveals, an increase in ACITR by one percent reduces the return on assets for commercial banks by approximately 0.4 percentage points two quarters after the tax increase. The effect fades out quickly. The response is highly significant, as indicated by the narrow 95 percent confidence bands.

Robustness checks reveal that the response of the return on assets is invariant to changes in the lag length for the endogenous variables, but not to changes in the exogenous variables (i.e. the tax narrative). Here, a minimum lag length of $s \geq 2$ is required to obtain our results. The fact that the response of the return on assets is only visible if at least two lags of the corporate income tax shocks are included suggests that the dynamics of banks' balance sheet conditions following a corporate income tax adjustment are not very well described by our baseline VAR.[30] In the following, we will therefore set $s = 2$. Note that our results for the baseline variables remain unchanged if we set $s = 2$ instead of $s = 1$.

We now turn to the question why corporate income tax changes affect balance sheet conditions of the financial sector. An obvious point that immediately comes to mind is that the return on assets declines because banks need to pay more taxes. If this was correct, then we should only see an effect on the after-tax return on assets, but not on the pre-tax return. This is not the case, as indicated by Figure 1.A.13, where we plot both the response of the pre-tax and of the after-tax return on assets for commercial banks. If anything, the response of the pre-tax return on assets is more pronounced. Hence, we conclude that tax liability changes in the financial sector are not the driver behind the impact of corporate tax adjustments on banks' balance sheet conditions. We will refer to our result that both pre-tax and after-tax return on assets respond to a corporate income tax change several times below.

The second hypothesis that we consider are changes in stock market returns, partly inspired by our previous results for personal income tax changes. Cutler (1988) summarizes theoretical evidence in support of this link, but fails to find a large market response to tax news empirically. If we incorporate the excess stock market return into Specification (1.4), we do not find a significant response either, as indicated by Figure 1.A.14. We therefore conclude that corporate income tax adjustments affect banks' balance sheet conditions via other channels than equity valuation changes. This result establishes a major difference between the transmission of personal and corporate income tax changes.

We now analyze whether the largest asset position of banks, their loan portfolio, is affected by corporate income tax changes. One could imagine that some of the banks' borrowers find it more difficult to repay their loans after an increase in corporate in-

[30] Indeed, we could have obtained the same results in an AR system (i.e. without endogenous variables other than the return on assets), as long as we would have kept $s \geq 2$.

come taxes. Through general equilibrium effects, borrowers might suffer either directly or indirectly from higher tax liabilities.

To test the consequences of corporate income tax adjustments for the quality of loans, we use the Bank Regulatory Database to construct a quarterly time series for the (annualized) provision for loan losses that banks make, relative to their total stock of loans. Data are available starting from the first quarter of 1976.[31] We incorporate the loan loss provisions/loan ratio as an additional endogenous variable into Specification (1.4).

The impulse response of the loan loss provisions/loan ratio to a one percent increase in ACITR is shown in Figure 1.A.15. Strikingly, the response of the loan loss provisions/loan ratio appears to be the mirror image of the response of the return on assets for commercial banks. In the second quarter following the tax increase, the loan loss provisions/loan ratio goes up by 0.6 percentage points, whereas the return on assets declines by 0.4 percentage points. The responses are highly significant for both variables, and both responses fade out quickly afterwards.[32]

According to general accounting principles, additions to loan loss reserves in the form of loan loss provisions are deducted from reported income in the period in which the provisions are made (Kuprianov 1997). Moreover, as noted by Kuprianov (1997), prior to the 1986 TRA, all banks were allowed to deduct additions to loan loss reserves up to a maximum from taxable income.[33] Banks therefore typically held loan loss reserves in excess of their expected losses. In particular, banks used loan loss reserves as a tax smoothing device (Balla, Rose, and Romero 2012).

The fact that we observe an increase in the loan loss provisions/loan ratio after a corporate tax adjustment could therefore indicate that banks raise their loan loss reserves solely to keep their after-tax profits constant. However, recall that, according to our previous results, pre-tax and after-tax returns change by roughly the same magnitude. We therefore conclude that banks do not increase the loan loss provisions/loan ratio to avoid to pay more corporate income taxes. Rather, the increase in the loan loss provisions/loan ratio appears to be the result of a deterioration in the quality of the loan portfolio.

We therefore investigate in which loan group banks experience an increase in non-performing loans. To do so, we use quarterly data from the Federal Deposit Insurance

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[31] Access to the Bank Regulatory Database was obtained through Wharton Research Data Services.

[32] If we had used loan loss reserves instead of loan loss provisions in the numerator, our results would have been qualitatively unchanged, which is to be expected, since loan loss reserves are the stock variable to which new loan loss provisions are added.

[33] As noted by Kuprianov (1997), after the 1986 TRA, this was only possible for 'small' banks with an asset volume below 500 million USD. Larger banks were only allowed to deduct loan loss provisions from their income statement in the year in which they accrued them. Small banks could continue to deduct loan loss provisions based on the 'experience method', which gave them more flexibility.

Corporation's Quarterly Banking Profile Database.[34] We focus on two major subgroups, real estate loans and commercial and industrial (C&I) loans. For these two subgroups, there are also sufficiently long time series available for non-performing loans, starting from 1984Q1. Non-performing loans are defined as loans that are more than 90 days past due or in non-accrual status. We normalize the number of non-performing loans by the number of total loans in the respective category, and include the resulting ratio as an endogenous variable into Specification (1.4).

As Figure 1.A.16 makes evident, following an increase in corporate income taxes, only the fraction of non-performing C&I loans increases significantly. Again, it is interesting to observe that the shape of the impulse response of non-performing C&I loans coincides almost perfectly with the reaction of the loan loss provisions/loan ratio.

Hence, we conclude that an increase in corporate bond spreads appears to affect banks' balance sheet conditions through an increase in the fraction of non-performing C&I loans. In the next subsection, we will investigate why this is the case.

The impact of corporate income tax changes on banks' balance sheet conditions: a detailed analysis focusing on specific tax acts. We now want to shed further light on why corporate income tax adjustments affect the fraction of non-performing C&I loans. As our previous analysis suggested, the increase in non-performing loans following an increase in corporate income taxes leads to higher loan loss provisions, relative to total loans. Consequently, banks' balance sheet conditions deteriorate, as indicated by the decline in the return on assets of banks.

There are four tax events that affected corporate income taxes in the period for which data on non-performing C&I loans are available, namely the TRA of 1986, the OBRA of 1987, the OBRA of 1990, and finally the JGTRRA of 2003.

To analyze which of the four tax acts accounts for the change in the fraction of non-performing C&I loans, we modify Specification (1.4) by incorporating $\Delta \text{tax}^{k,CI}$ $\forall\ k \in \{1986, 1987, 1990, 2003\}$, where k indicates one of the four tax events. $\Delta \text{tax}^{k,CI}$ measures the change in corporate tax liabilities/corporate tax base for one of the four tax acts. The new system then looks as follows:

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=0}^{s} B_j^{k,CI} \Delta \text{tax}_{t-j}^{k,CI} + D + Et + u_t \quad \forall k \in \{1986, 1987, 1990, 2003\} \quad (1.5)$$

The vector of endogenous variables y consists of our baseline variables (including APITR and ACITR) and the fraction of non-performing C&I loans. We set $p = s = 2$. Our results are robust to different choices of s and p as long as $s \geq 2$. We are interested in the

[34] `https://www2.fdic.gov/qbp/index.asp`, retrieved May 26, 2015.

dynamic multiplier $D^{k,CI}(L) := A(L)^{-1}B^{k,CI}(L)\ \forall\ k \in \{1986, 1987, 1990, 2003\}$. D and E control for a constant and a time trend.

Note that the magnitude of the responses found by considering Specification (1.4), where we measure the impact of all corporate income tax changes, cannot be compared to the magnitude of the responses obtained from Specification (1.5), due to differences in scaling. Specification (1.5) resembles the dummy variable approach employed in Ramey and Shapiro (1998) and in Burnside, Eichenbaum, and Fisher (2004). In the following, we will therefore focus on whether the impulse response is significant, and not on the size of the multiplier. Also note that in order to ensure consistency with our other results, when we plot the respective impulse responses, we consider the impulse response after a tax increase, even if a specific tax event entailed a decline in corporate income taxes.

In Figure 1.A.17, we present the response of the fraction of non-performing loans for each of the aforementioned tax acts. Interestingly, only the 1986 TRA appears to have a significant impact on non-performing loans. Moreover, the shape of the impulse response looks strikingly similar to the one that we obtained from considering all corporate income tax changes. In sum, this suggests that the effects of corporate income tax changes on the fraction of non-performing loans are entirely driven by the 1986 TRA.

If we analyze the response of the loan loss provisions/loan ratio using Specification (1.5), we also find that the 1986 TRA is responsible for the aggregate effect, see Figure 1.A.18.[35] Our results furthermore indicate that the 1986 TRA is the driving force behind the responses of the return on assets and of FBP to corporate income tax changes, as is depicted in Figures 1.A.19 and 1.A.20 respectively.[36] On the other hand, we cannot detect any relationship between the 1986 TRA and EBP, see Figure 1.A.21.

Note that our observation that the 1986 TRA affects FBP but not EBP is perhaps surprising. In particular, in light of our other finding that the 1986 TRA has an impact on the return on assets. Since banks observe a deterioration of their balance sheet conditions following the 1986 TRA, we would expect that they require a higher risk premium, as reflected in an increase in the excess bond premia, independently of whether corporate bonds are issued by financial or non-financial firms. Our result that only FBP responds to the 1986 TRA therefore also stands in contrast to our previous analysis for the 2003

[35]Note that there is a negative reaction of the loan loss provisions/loan ratio after the 1987 OBRA. According to the theory outlined in Section 1.5, this would imply a decrease in FBP. As shown in Figure 1.A.20, the opposite is the case. Moreover, the 1987 OBRA does not have a significant impact on the return on assets of commercial banks, as depicted in Figure 1.A.19. Therefore, we conclude that the response after the 1987 OBRA is not driven by banks' balance sheet conditions and therefore, we do not analyze the 1987 OBRA in further detail.

[36]Note that FBP also responds significantly to the 1990 OBRA. However, since there is no response of the return on assets of commercial banks, we conclude that banks' balance sheet conditions cannot be the reason for this effect. We therefore leave it to future research to analyze why FBP responds to the 1990 OBRA.

JGTRRA, which has an impact on banks' return on assets and on EBP, but not on FBP. We will further comment on this issue later.

The importance of the 1986 TRA. We now analyze in more detail how the 1986 TRA affects the fraction of non-performing C&I loans. Since we do not have information about the sectoral composition of non-performing C&I loans, we are forced to take an indirect approach.

We first construct a time series for the failure rates of firms for all sectors. This allows us to find out which industries experienced an increase in their firms' failure rates after the implementation of the 1986 TRA. In a second step, we then analyze whether the sectors that experienced an increase in their failure rates also depend on bank loans. In a third step, we link the increase in firms' failure rates in the aftermath of the 1986 TRA to the rise in the fraction of non-performing C&I loans.

We compute failure rates of firms using data on firm death from the Business Dynamics Survey (BDS).[37] According to the BDS definition, a firm died in a specific year if it exited in its entirety during this year. To be considered a firm death, all establishments owned by the firm must exit.[38] We calculate the failure rate in a specific sector by dividing the number of exiting firms in a given year by the total number of firms in that sector. Note that data are available on a yearly basis only. This prevents us from formally studying the response of the sector-specific failure rates to the 1986 TRA by incorporating the failure rate as an endogenous variable in our quarterly VAR.

Instead, we plot in Figure 1.A.22 the sector-specific failure rates for agriculture, construction, manufacturing, mining, retail trade, wholesale trade, services, and finance, insurance and real estate. For most sectors, failure rates are stable across years, with the exception of mining, which experienced a sharp increase in its failure rate in 1987, the year after the 1986 TRA was implemented.

This suggests that firm failures in the mining industry could be the reason for the increase in non-performing loans in the aftermath of the 1986 TRA.[39] Firms in the mining

[37] `http://www.census.gov/ces/dataproducts/bds/data_firm.html`, retrieved on May 26, 2015.

[38] BDS Codebook, page 5. Note that this definition is quite narrow. According to the codebook, "[...] a firm with 100 establishments would not qualify as a firm death if 99 exited while 1 continued under different ownership." (page 5).

[39] It is perhaps surprising that the construction sector does not appear to be important. As noted above, one of the main objectives of the 1986 TRA was to 'level the playing field', which also meant to abolish investment in tax shelters. As noted by Poterba (1992), rental housing was one of the most actively used tax shelters in the beginning of the 1980s. The 1986 TRA is therefore typically associated with the downturn in the real estate segment, in particular with the decline in the construction industry (see again Poterba 1992). Indeed, Figure 1.A.22 shows a minor increase in failure rates of firms in the construction sector, but only in 1988. Compared to the spike in the failure rate in the mining sector, this increase is negligible. This suggests that firm failures in the construction sector cannot be responsible for the rise in the fraction of non-performing loans in banks' balance sheets. Moreover, according to our

sector depend strongly on bank loans, a fact that can be seen from the high bank loan/asset ratio, which is equal to 12 percent according to the data from the 1987 Quarterly Financial Report (QFR).[40] The bank loan/asset ratio in the mining industry is high, even compared to other capital-intensive sectors covered by the 1987 QFR, such as manufacturing. For manufacturing, the bank loan/asset ratio is only 8 percent.

We now analyze whether the increase in the failure rate of firms in the mining sector can potentially account for the rise in the fraction of non-performing C&I loans that we documented earlier. Figure 1.A.22 suggests that the failure rate in the mining industry increased between 1986 and 1987 by almost 30 percent, from 13.5 percent to 17.5 percent. Using the 1987 QFR, we find that bank loans to firms in the mining sector account for 3.5 percent of all bank loans to the sectors covered by the QFR.

Under the assumption that an increase in the firms' failure rate by 30 percent directly translates into an increase in the fraction of non-performing C&I loans in the mining sector, this suggests that we should see a rise of approximately one percentage point in the fraction of non-performing loans in the year after the 1986 TRA. Interestingly, our results for all corporate income tax changes (where it makes sense to consider magnitudes since we appropriately scale) indicate that increasing ACITR by one percent leads to a rise in the fraction of non-performing loans by around 0.6 percentage points.

The fact that not all sectors are covered by the QFR understates the total volume of bank loans. In this context, it is important to note that probably some firms from other sectors also failed as a consequence of the 1986 TRA, without affecting the aggregate failure rate in their respective sector. Heavy industries, for example, are part of the manufacturing sector. The number of firms in heavy industries is small, relative to the overall number of firms in the manufacturing sector. So it is unlikely that an increase in the failure rate in heavy industries leads to a rise in the overall failure rate in the manufacturing sector.[41]

Moreover, it is very likely that heavy industries also suffered from the 1986 TRA. One of the main objectives of the 1986 TRA was to 'level the playing field', see Poterba (1992). This required a broadening of the tax base by reducing investment in tax shelters and by abolishing tax deductions. Losers of the reform were therefore firms in capital-intensive

impulse responses, the peak in the fraction of non-performing loans occurred three quarters after the implementation of the 1986 TRA in December 1986, which suggests that most of the action took place in 1987, the year after the implementation of the 1986 TRA.

[40] `http://www.census.gov/econ/qfr/historic.html`, retrieved on May 26, 2015. We define bank loans as the sum of STBANK (short term debt in form of bank loans) + INSTBANKS (long-term debt in form of bank loans, due in less than one year) + LTBNKDEBT (long-term debt in form of bank loans, due in more than one year).

[41] Unfortunately, the Business Dynamics Survey does not allow for a finer breakdown of the sector-specific failure rate.

sectors, such as mining or heavy industries. According to the calculations presented in Cutler (1988), heavy industries and mining were the two sectors that were predicted to experience the largest loss in their net income following the 1986 TRA.

An increase in failure rates for heavy industries is also likely to affect the fraction of non-performing C&I loans, since, according to the 1987 QFR, bank loans to heavy industries account for 4.5 percent of total bank loans.

Explaining the differential impact of the 1986 TRA and the 2003 JGTRRA on EBP and FBP. As a final remark, we want to comment on another observation that is implicit in our previous results. It seems that the 1986 TRA only affects FBP but not EBP, whereas the 2003 JGTRRA (respectively all personal income tax changes) has a significant impact on EBP only.

This finding is perhaps puzzling. After all, both tax acts have an impact on financial intermediaries' balance sheet conditions and should therefore affect the risk premium that financial intermediaries require to hold corporate bonds, independently of whether the bonds are issued by financial or by non-financial firms.

In order to understand this puzzle, note that the risk premium is determined by the correlation of two types of shocks. The first shock determines the default risk of corporate bonds. For future reference, we denote this the 'type one' shock. The second shock governs the financial intermediaries' balance sheet conditions and therefore implicitly the risk premium that intermediaries require to accept corporate bonds, conditional on type one risk. We call this shock the 'type two' shock.

We believe that the solution to the puzzle that the 1986 TRA affects FBP only, but not EBP, lies in the correlation of type one and type two shocks. The following example illustrates this. In the language of our two shocks, an increase in non-performing loans – as we observe it after the 1986 TRA – is a type two shock that tightens the balance sheet conditions of a specific intermediary. At the same time, it is also a type one shock for corporate bonds of financial firms, because an increase in non-performing loans in the aggregate affects the balance sheet conditions of all other financial firms as well. Therefore, type one and type two shocks are positively correlated if a financial firm wants to buy the corporate bonds issued by another financial firm. In this case, it will demand a higher risk premium, reflected in an increase in FBP. The increase in non-performing loans does not constitute a shock to corporate bonds issued by non-financial firms.[42] Therefore, financial firms can avoid the positive correlation between type one and type two shocks by buying

[42]This assumes that firms that have difficulties repaying their bank loans are not the same as the ones that issue corporate bonds, e.g. because they belong to a different sector, or because they are larger and are therefore to some extent sheltered from the negative shocks that affect firms that depend on bank loans.

corporate bonds issued by non-financial firms. As a result, we do not observe an increase in EBP.

Consider now the 2003 JGTRRA. In the language of our example, equity valuation changes constitute a type two shock. Moreover, since changes in equity valuation also affect balance sheet conditions of firms that issue corporate bonds, they also constitute a type one shock. Therefore, we would expect that the 2003 JGTRRA has an impact on both EBP and FBP. This is definitely the case for EBP. However, for FBP, the relationship is difficult to detect because its response to all personal income tax changes is already insignificant. We therefore conclude that the correlation between type one and type two shocks for financial firms is not strong enough to generate a significant response of FBP. This is most likely due to the fact that FBP is only available from 1985Q1 onwards, which limits the degrees of freedom and therefore increases the variance of its estimated response.

1.6.3 Robustness Check: Controlling for Personal and Corporate Income Tax Changes at the Same Time

We now check whether our previous results are robust to controlling for both personal and corporate income tax changes. We therefore re-estimate our (baseline) Specification (1.2), but this time, we use both Δtax^{PI} and Δtax^{CI} as exogenous variables:

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=0}^{s} B_j^{PI} \Delta\text{tax}_{t-j}^{PI} + \sum_{j=0}^{s} B_j^{CI} \Delta\text{tax}_{t-j}^{CI} + D + Et + u_t \tag{1.6}$$

We incorporate the same endogenous variables as in Specification (1.2). In addition, we also include one of our variables of interest, i.e. either EBP, FBP, the return on assets of commercial banks, the loan loss provisions/loan ratio or the fraction of non-performing C&I loans. We consider $p = 2$ lags for the endogenous variables, and we set the number of lags for the exogenous variables to $s = 2$, in order to allow for a lagged impact of tax liability changes on the endogenous variables. D and E again control for a constant and a linear time trend.

It should be noted that in Specification (1.6), identification hinges on those tax acts for which personal and corporate income tax changes have a different sign. Since data on non-performing C&I loans are only available from 1984Q1 onwards, there are four tax acts that affect corporate income taxes, namely the TRA of 1986, the OBRA of 1987, the OBRA of 1990, and finally the JGTRRA of 2003. As shown in Figure 1.A.5, the 1986 TRA is the only tax act for which personal income taxes and corporate income taxes are adjusted in opposite directions.

Strikingly, we find that our previous results reported in Figures 1.A.12 - 1.A.21 regarding a one percent increase in ACITR remain unchanged, even if we control for personal income tax changes. To save space, the corresponding figures are omitted.[43] The only exception is the response of EBP, which becomes insignificant after incorporating Δtax^{PI}.

The reason is that the response of EBP is entirely driven by the 2003 JGTRRA. Recall from our previous results that the response of EBP becomes insignificant as soon as we drop the personal income tax component associated with the 2003 JGTRRA from our sample of personal income tax changes. Since the 2003 JGTRRA changes personal income taxes and corporate income taxes in the same direction, we cannot separate the impact of the two tax categories using Specification (1.6). As a result, the response becomes insignificant as soon as we incorporate Δtax^{PI}.

Thus, the following concern arises. It could be that it is not the personal income tax component of the 2003 JGTRRA that is important for the impact of the 2003 JGTRRA on corporate bond spreads, financial intermediaries' balance sheet conditions, and stock market returns, but rather the change in corporate income taxes associated with the 2003 JGTRRA. And similarly, it could be that the 1986 TRA affects banks' balance sheet conditions, and therefore corporate bond spreads, through the adjustment of personal income taxes. We will analyze this point in the next subsection in greater detail. Specifically, we will show that this is not the case.

A comparison of two tax acts and their impact on banks' balance sheets: 1986 TRA versus 2003 JGTRRA. We now argue that, by combining our evidence for the 1986 TRA and for the 2003 JGTRRA, we can infer that the 1986 TRA operates through corporate income tax adjustments, whereas the 2003 JGTRRA affects financial intermediaries' balance sheet conditions via its personal income tax component.

Our main observation is that the two tax acts change intermediaries' balance sheets through different channels. Key for our argumentation is the fact that determinants of intermediaries' balance sheets that are more likely to respond after an adjustment in personal income taxes are affected by the 2003 JGTRRA, whereas the 1986 TRA appears to change determinants that are more likely to be affected by corporate income tax changes.

Before we turn to the details, recall from Figure 1.A.5 that the 1986 TRA is by far the most important corporate income tax change in our sample, whereas the 2003 JGTRRA had a major impact on personal income taxation.

Now, consider the 2003 JGTRRA in greater detail. We previously documented that this tax act gives rise to changes in (excess) stock market returns. Stocks are the second most important component of financial intermediaries' assets, after loans. The quality of

[43] They are available from the authors upon request.

loans does not appear to be affected by the 2003 JGTRRA, since we concluded above that the 1986 TRA is able to explain the response of non-performing loans and of the loan loss provisions/loan ratio that we observe using all tax changes. Given that the 2003 JGTRRA affects the return on assets for financial intermediaries, it seems likely that excess stock market returns matter for the transmission of the 2003 JGTRRA to intermediaries' balance sheet conditions.

Regarding the question whether the response of stock market returns is a consequence of adjustments in personal or in corporate income taxation, we note that the 2003 JGTRRA entails by far the most significant dividend/capital gain tax change in our sample. There is evidence by Sialm (2009) and others that dividend/capital gain taxes influence equity valuations. In contrast, there is no such strong evidence for the impact of corporate income tax changes on aggregate stock prices, see Cutler (1988). Since dividend/capital gain taxes are part of the personal income tax component of the 2003 JGTRRA, we conclude that the 2003 JGTRRA affects stock market returns through adjustments in personal income taxation.

We now turn to the 1986 TRA. As noted above, corporate income tax changes in general and especially the 1986 TRA do not have an impact on excess stock market returns. For the 1986 TRA, this finding is to be expected, given that it only had a minor impact on dividend/capital gain taxes (see e.g. Figure 1 in Sialm 2009). Instead, we argued above that the 1986 TRA affects banks' balance sheet conditions through changes in the fraction of non-performing C&I loans. Arguably, it is more likely that these changes in the fraction of non-performing C&I loans stem from a corporate income tax adjustment, and not from a personal income tax change.

In conclusion, we find that our results are robust to controlling for both personal and corporate income tax changes. In particular, we argue that the 1986 TRA affects financial intermediaries' balance sheets via its corporate income tax component, whereas the 2003 JGTRRA operates through its personal income tax component.

1.7 Conclusion

In this paper, we empirically document that tax changes affect financial market conditions. Using the Romer and Romer (2010) narrative record of exogenous federal tax liability changes for the US, we show that an increase in taxes leads to higher risk premia for corporate bonds issued by financial and non-financial firms. Using additional information by Mertens and Ravn (2013), which allows us to distinguish between personal and corporate income taxation, we find that risk premia are driven by financial intermediaries' balance sheet conditions, a result that is consistent with recent theories of intermediary asset pricing, such as He and Krishnamurthy (2013) and Brunnermeier and Sannikov (2014). Moreover, we also analyze in detail how intermediaries' balance sheet conditions respond to tax changes.

Two tax acts turn out to be particularly important, namely the Tax Reform Act (TRA) of 1986 and the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) of 2003. Interestingly, none of these two tax acts specifically targeted the financial sector. Therefore, a general conclusion that emerges from our analysis is that any tax change can potentially spill over to financial market conditions, with the associated consequences for the real economy.

A promising avenue for future research could therefore be to analyze the effect of tax changes on real economic activity in a macro model with financial frictions, for example by using a model that features a financial accelerator, such as Bernanke and Gertler (1995), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (1999).[44] However, as we note in our companion paper, Kraus and Winter (2015b), a tax increase might not always lead to tighter financial frictions in this class of models. The exact response depends on the tax instrument and on the model environment considered.[45]

Moreover, in our companion paper, we conclude that models in which the frictions affect financial intermediaries, such as e.g. Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and Gertler, Kiyotaki, and Queralto (2012) are more promising in explaining the response of real economic activity to tax changes.[46]

Incorporating financial intermediaries into a model to study the transmission of tax changes would also be consistent with our finding that tax changes affect the return on assets of the financial sector empirically. Here, further research could shed more light on the channels through which taxes affect intermediaries' balance sheet conditions. For example, more detailed information regarding the sectoral composition of commercial banks' C&I loans could be gathered in order to test whether the increase in the fraction of non-performing loans after the 1986 TRA is indeed connected to the increase in the

[44] See Quadrini (2011) for a recent survey.

[45] For example, in Fernández-Villaverde (2010), an increase in taxes implies higher inflation, which in turn raises entrepreneurs' net worth (in nominal terms), thereby reducing the external finance premium. Strulik (2008) studies the consequences of various forms of capital tax changes in a financial accelerator model à la Bernanke, Gertler, and Gilchrist (1999). He finds that an increase in the private capital income tax reduces the tax advantage of debt finance as opposed to equity, which in turn decreases leverage and therefore also the external finance premium. The opposite is the case after an increase in corporate income taxation. The findings by Strulik (2008) therefore show the importance of the specific tax instrument considered.

[46] This is because investment distortions (in the form of interest rate spreads) for durables and capital investment are needed in order to account for the empirical effects of a tax change. Since durables are purchased by households, models in which only firms are subject to financial frictions cannot generate an interest rate spread for durables purchases. In contrast, financial frictions at the level of the financial intermediary would be able to affect all lending activities.

failure rate of firms in the mining sector.

Another interesting avenue for further research would be to analyze alternative channels through which taxes could affect corporate bond spreads. Such an alternative channel could for example be changes in the supply of government bonds (see Krishnamurthy and Vissing-Jorgensen 2012). Further research could also clarify whether this channel can explain the increase in FBP following the 1990 Omnibus Budget Reconciliation Act (OBRA), which is shown in Figure 1.A.20.

1.A Appendix

1.A.1 Data

The data used in our estimation are based on Romer and Romer (2009, 2010) and on the Online Appendix of Mertens and Ravn (2013). There are a few differences between our dataset and the one used by Romer and Romer (2009, 2010):

- We use a different timing convention than Romer and Romer (2009, 2010) and date every tax change in the quarter in which it was actually implemented. Romer and Romer (2009, 2010), on the other hand, only assign tax changes in the first half of the quarter to this same quarter, whereas tax changes that occurred after the midpoint of the quarter are assigned to the next quarter.

- We distinguish between anticipated and unanticipated tax changes. Specifically, we have three measures for unanticipated tax changes, depending on the lag between the announcement and implementation date: same month (called S1 in Table 1.A.1), 30 days (called S1-exceptions in Table 1.A.1) and 90 days (called S3 in Table 1.A.1). The measures we use – if not stated otherwise – are the S1-exceptions tax changes.

- We add the distinction between personal, corporate, and other tax changes, using the data from the Online Appendix by Mertens and Ravn (2013). The exact decomposition between the different categories is shown in the last three columns of Table 1.A.2. In three cases, the personal, corporate, and other tax changes do not sum up to the total amount reported by Romer and Romer (2009, 2010). This is due to adjustments made by Mertens and Ravn (2013) and is marked with an asterisk in Table 1.A.2. Note that the decomposition into personal, corporate, and other tax changes is only available for those tax events with an implementation lag of less than one quarter.

Table 1.A.1: Timing of exogenous tax changes

	Tax Act	Signed	Effective	S1	S1 + exceptions	S3	Our Timing	R&R Timing
1	Social Security Amendments of 1947	06/08/1947	01/1950	NO	NO	NO	1950Q1	1950Q1
2	Revenue Act of 1948	02/04/1948	04/1948	YES	YES	YES	1948Q2	1948Q2
3	Social Security Amendments of 1950	28/08/1950	01/1954	NO	NO	NO	1954Q1	1954Q1
4	Expiration of Excess Profits Tax and Temporary Income Tax Increases	10/1951	01/1954	NO	NO	NO	1954Q1	1954Q1
5	Internal Revenue Code of 1954	16/08/1954	08/1954	YES	YES	YES	1954Q3	1954Q4
6	Tax Rate Extension Act of 1958	30/06/1958	07/1958	NO	YES	YES	1958Q3	1958Q3
7	Social Security Amendments of 1958	28/08/1958	01/1960	NO	NO	NO	1960Q1	1960Q1
8	Federal-Aid Highway Act of 1959	21/09/1959	10/1959	NO	YES	YES	1959Q4	1959Q4
9	Social Security Amendments of 1958	30/06/1961	01/1963	NO	NO	NO	1963Q1	1963Q1
10	Changes in Depreciation Guidelines	11/07/1962	07/1962	YES	YES	YES	1962Q3	1962Q3
	and Revenue Act of 1962	16/10/1962	10/1962	YES	YES	YES	1962Q4	1962Q4
		16/10/1962	01/1963	NO	NO	NO	1963Q1	1963Q1
11	Revenue Act of 1964	26/02/1964	02/1964	YES	YES	YES	1964Q1	1964Q2
		26/02/1964	01/1965	NO	NO	NO	1965Q1	1965Q1
12	Excise Tax Reduction Act of 1965	21/06/1965	06/1965	YES	YES	YES	1965Q2	1965Q3
		21/06/1965	01/1966	NO	NO	NO	1966Q1	1966Q1
13	Tax Adjustment Act of 1966	15/03/1966	03/1966	YES	YES	YES	1966Q1	1966Q2
14	Public Law 90-26	13/06/1967	06/1967	YES	YES	YES	1967Q2	1967Q3
15	Social Security Amendments of 1967	02/01/1968	01/1971	NO	NO	NO	1971Q1	1971Q1
16	Tax Reform Act of 1969	30/12/1969	01/1971	NO	NO	NO	1971Q1	1971Q1
		30/12/1969	01/1972	NO	NO	NO	1972Q1	1972Q1
17	Reform of Depreciation Rules	11/01/1971	01/1971	YES	YES	YES	1971Q1	1971Q1
18	Revenue Act of 1971	10/12/1971	01/1972	NO	YES	YES	1972Q1	1972Q1
19	1972 Changes to Social Security	30/10/1972	01/1978	NO	NO	NO	1978Q1	1978Q1
20	Tax Reform Act of 1976	04/10/1976	10/1976	YES	YES	YES	1976Q4	1976Q4
		04/10/1976	01/1977	NO	NO	NO	1977Q1	1977Q1
21	Tax Reduction and Simplification Act of 1977	23/05/1977	05/1977	YES	YES	YES	1977Q2	1977Q3
22	Social Security Amendments of 1977	20/12/1977	01/1979	NO	NO	NO	1979Q1	1979Q1
		20/12/1977	01/1980	NO	NO	NO	1980Q1	1980Q1
		20/12/1977	01/1981	NO	NO	NO	1981Q1	1981Q1
		20/12/1977	01/1982	NO	NO	NO	1982Q1	1982Q1
23	Revenue Act of 1978	06/11/1978	01/1979	NO	NO	YES	1979Q1	1979Q1
24	Crude Oil Windfall Profit Tax Act	02/04/1980	04/1980	YES	YES	YES	1980Q2	1980Q2
	of 1980	02/04/1980	01/1981	NO	NO	NO	1981Q1	1981Q1
		02/04/1980	01/1982	NO	NO	NO	1982Q1	1982Q1
25	Economic Recovery Tax Act of 1981	13/08/1981	08/1981	YES	YES	YES	1981Q3	1981Q3
		13/08/1981	01/1982	NO	NO	NO	1982Q1	1982Q1
		13/08/1981	01/1983	NO	NO	NO	1983Q1	1983Q1
		13/08/1981	01/1984	NO	NO	NO	1984Q1	1984Q1
26	Tax Equity and Fiscal Responsibility Act of 1982	03/09/1982	01/1983	NO	NO	NO	1983Q1	1983Q1
27	Social Security Amendments of 1983	20/04/1983	01/1984	NO	NO	NO	1984Q1	1984Q1
		20/04/1983	01/1985	NO	NO	NO	1985Q1	1985Q1
		20/04/1983	01/1986	NO	NO	NO	1986Q1	1986Q1
		20/04/1983	01/1988	NO	NO	NO	1988Q1	1988Q1
		20/04/1983	01/1990	NO	NO	NO	1990Q1	1990Q1
28	Deficit Reduction Act of 1984	18/07/1984	07/1984	YES	YES	YES	1984Q3	1984Q3
29	Tax Reform Act of 1986	22/10/1986	10/1986	YES	YES	YES	1986Q4	1986Q4
		22/10/1986	01/1987	NO	NO	NO	1987Q1	1987Q1
		22/10/1986	07/1987	NO	NO	NO	1987Q3	1987Q3
		22/10/1986	01/1988	NO	NO	NO	1988Q1	1988Q1
30	Omnibus Budget Reconciliation Act of 1987	22/12/1987	01/1988	NO	YES	YES	1988Q1	1988Q1
31	Omnibus Budget Reconciliation Act of 1990	05/11/1990	01/1991	NO	NO	YES	1991Q1	1991Q1
32	Omnibus Budget Reconciliation Act of	10/08/1993	08/1993	YES	YES	YES	1993Q3	1993Q3
	1993	10/08/1993	10/1993	NO	NO	YES	1993Q4	1993Q4
		10/08/1993	01/1994	NO	NO	NO	1994Q1	1994Q1
33	Taxpayer Relief Act of 1997 and	05/08/1997	01/2000	NO	NO	NO	2000Q1	2000Q1
	Balanced Budget Act of 1997	05/08/1997	01/2002	NO	NO	NO	2002Q1	2002Q1
34	Economic Growth and Tax Relief Reconciliation Act of 2001	07/06/2001	01/2002	NO	NO	NO	2002Q1	2002Q1
35	Jobs and Growth Tax Relief	28/05/2003	05/2003	YES	YES	YES	2003Q2	2003Q3
	Reconciliation Act of 2003	28/05/2003	01/2005	NO	NO	NO	2005Q1	2005Q1

Table 1.A.2: Size and category of exogenous tax changes

	Tax Act	Our Timing	Total Amount (in billion)	Deficit-Driven	Long-Run	Personal	Corporate	Other
1	Social Security Amendments of 1947	1950Q1	0.75	0.75				
2	Revenue Act of 1948	1948Q2	-5.00		-5.00	-5.00		
3	Social Security Amendments of 1950	1954Q1	1.30	1.30				
4	Expiration of Excess Profits Tax and Temporary Income Tax Increases	1954Q1	-1.30	-1.30				
5	Internal Revenue Code of 1954	1954Q3	-1.40		-1.40	-0.80	-0.60	
6	Tax Rate Extension Act of 1958	1958Q3	-0.50		-0.50			-0.50
7	Social Security Amendments of 1958	1960Q1	1.90	1.90				
8	Federal-Aid Highway Act of 1959	1959Q4	0.60	0.60				0.60
9	Social Security Amendments of 1958	1963Q1	2.00	2.00				
10	Changes in Depreciation Guidelines	1962Q3	-1.35		-1.35		-1.35	
	and Revenue Act of 1962	1962Q4	-0.90		-0.90		-0.90	
		1963Q1	0.60		0.60			0.60
11	Revenue Act of 1964	1964Q1	-8.40		-8.40	-6.70	-1.70	
		1965Q1	-4.50		-4.50			
12	Excise Tax Reduction Act of 1965	1965Q2	-1.75		-1.75			-1.75
		1966Q1	-1.75		-1.75			
13	Tax Adjustment Act of 1966	1966Q1	0.90		0.90			0.90
14	Public Law 90-26	1967Q2	-1.60		-1.60		-1.60	
15	Social Security Amendments of 1967	1971Q1	3.60	3.60				
16	Tax Reform Act of 1969	1971Q1	-1.00		-1.00			
		1972Q1	-1.00		-1.00			
17	Reform of Depreciation Rules	1971Q1	-2.80		-2.80		-2.80	
18	Revenue Act of 1971	1972Q1	-8.00		-8.00	-3.80	-1.60	-2.60
19	1972 Changes to Social Security	1978Q1	2.90	2.90				
20	Tax Reform Act of 1976	1976Q4	2.40		2.40	1.65	0.75	
		1977Q1	-0.80		-0.80			
21	Tax Reduction and Simplification Act of 1977	1977Q2	-7.00		-7.00	-5.40	-1.60	
22	Social Security Amendments of 1977	1979Q1	8.80	8.80				
		1980Q1	1.70	1.70				
		1981Q1	17.20	17.20				
		1982Q1	1.50	1.50				
23	Revenue Act of 1978	1979Q1	-18.90		-18.90	-14.80	-6.50	
24	Crude Oil Windfall Profit Tax Act	1980Q2	8.20		8.20			8.20
	of 1980	1981Q1	4.10		4.10			
		1982Q1	4.10		4.10			
25	Economic Recovery Tax Act of 1981	1981Q3	-8.90		-8.90			
		1982Q1	-48.80		-48.80			
		1983Q1	-57.30		-57.30			
		1984Q1	-36.10		-36.10			
26	Tax Equity and Fiscal Responsibility Act of 1982	1983Q1	26.40	26.40				
27	Social Security Amendments of 1983	1984Q1	12.10	12.10				
		1985Q1	8.80	8.80				
		1986Q1	4.20	4.20				
		1988Q1	15.50	15.50				
		1990Q1	10.30	10.30				
28	Deficit Reduction Act of 1984	1984Q3	8.00	8.00		5.6*	3.3*	0.4*
29	Tax Reform Act of 1986	1986Q4	22.70		22.70		22.70	
		1987Q1	-7.20		-7.20	-7.20		
		1987Q3	-20.00		-20.00			
		1988Q1	-7.20		-7.20			
30	Omnibus Budget Reconciliation Act of 1987	1988Q1	10.80	10.80		0.80	7.50	2.50
31	Omnibus Budget Reconciliation Act of 1990	1991Q1	35.20	35.20		14.00*	1.00*	18.00*
32	Omnibus Budget Reconciliation Act of	1993Q3	22.80	22.80		22.80		
	1993	1993Q4	5.30	5.30				5.30
		1994Q1	13.40	13.40				
33	Taxpayer Relief Act of 1997 and	2000Q1	1.70	1.70				
	Balanced Budget Act of 1997	2002Q1	0.60	0.60				
34	Economic Growth and Tax Relief Reconciliation Act of 2001	2002Q1	-83.00		-83.00			
35	Jobs and Growth Tax Relief	2003Q2	-126.40		-126.40	-94.6*	-31.2*	
	Reconciliation Act of 2003	2005Q1	68.10		68.10			

Notes: *=deviations from the total amount by Romer and Romer (2009) are due to corrections made by Mertens and Ravn (2013)

Table 1.A.3: Sources and descriptions of variables

Variable	Description	Source
GDP	Nominal GDP, seasonally adjusted, in billions of USD; divided by the GDP deflator (2005=100) and by population.	FRED, St. Louis Fed
Durables Consumption	Nominal personal consumption expenditures on durable goods, seasonally adjusted, in billions of USD; divided by the durables expenditures deflator (2005=100) and by population.	FRED, St. Louis Fed
Non-Durables Consumption	Nominal personal consumption expenditures on non-durable goods, seasonally adjusted, in billions of USD; divided by the deflator for non-durable consumption (2005=100) and by population.	FRED, St. Louis Fed
Investment	Nominal gross private domestic investment, seasonally adjusted, in billions of USD; divided by the private investment deflator (2005=100) and by population.	FRED, St. Louis Fed
Hours	Product of hours worked and civilian non-farm employment; divided by population.	Dataset from Mertens and Ravn (2012)
Tax Revenues / GDP	Federal government current tax receipts, seasonally adjusted annual rate; divided by nominal GDP.	FRED, St. Louis Fed
Excess Bond Premium for Non-Financial Firms (EBP)	See description in Section 1.2.2 and Gilchrist and Zakrajsek (2012).	Dataset from Gilchrist and Zakrajsek (2012)
Excess Bond Premium for Financial Firms (FBP)	See description in Section 1.2.2 and Gilchrist and Zakrajsek (2011).	Dataset from Gilchrist and Zakrajsek (2011)

Table 1.A.3: Sources and descriptions of variables

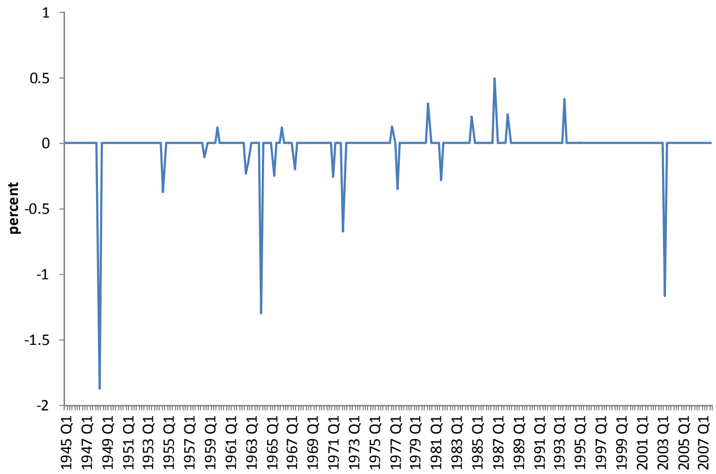
Variable	**Description**	**Source**
Average Personal Income Tax Rate (APITR)	APITR is defined as the sum of personal current taxes and contributions to government social insurance; divided by personal taxable income.	FRED, St. Louis Fed
Average Corporate Income Tax Rate (ACITR)	ACITR is defined as taxes on corporate profits; divided by corporate profits. Profits by Federal Reserve Banks are excluded.	FRED, St. Louis Fed
Pre-Tax Return on Assets of Commercial Banks	Pre-tax income (variable PIQ)/total assets (variable ATQ), annualized, in percent. Commercial Banks: all institutions with NAICS code 522.	Constructed from Compustat
After-Tax Return on Assets of Commercial Banks	Income before extraordinary items (variable IBQ)/total assets (variable ATQ), annualized, in percent. Commercial Banks: all institutions with NAICS code 522.	Constructed from Compustat
Return on Assets of the Aggregate Financial Sector	See Gilchrist and Zakrajsek (2012). Data are annualized, in percent.	Dataset from Gilchrist and Zakrajsek (2012)
Loan Loss Provisions / Loan Ratio	Ratio of loan loss provisions (variable riad4230) to total loans, net of unearned income (variable rcon2122), annualized, in percent.	Bank Regulatory Database
Fraction of Non-Performing C&I Loans	Non-performing loans are defined as loans that are more than 90 days past due or in non-accrual status, in percent of total outstanding C&I loans.	Federal Deposit Insurance Corporation's Quarterly Banking Profile Database
Fraction of Non-Performing Real Estate Loans	Non-performing loans are defined as loans that are more than 90 days past due or in non-accrual status, in percent of total outstanding real estate loans.	Federal Deposit Insurance Corporation's Quarterly Banking Profile Database

Table 1.A.3: Sources and descriptions of variables

Variable	**Description**	**Source**
Excess Stock Market Return	Difference between the quarterly (value-weighted) stock market return (including dividends) of the New York Stock Exchange minus the return on short-run (3 months) T-Bills, annualized, in percent.	Constructed using data from the Center for Research in Security Prices (CRSP)
Price / Dividend Ratio	Stock market data used in "Irrational Exuberance", Princeton University Press, 2000, 2005, 2015, updated, see Shiller (2005).	`http://www.econ.yale.edu/~shiller/data/ie_data.xls`, retrieved on May 19, 2015
Cyclically Adjusted Price / Earnings Ratio	Stock market data used in "Irrational Exuberance", Princeton University Press, 2000, 2005, 2015, updated, see Shiller (2005).	`http://www.econ.yale.edu/~shiller/data/ie_data.xls`, retrieved on May 19, 2015

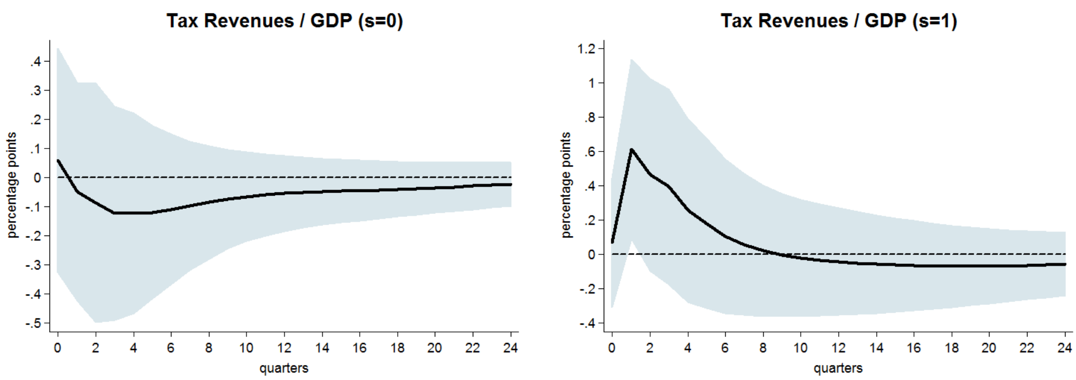
1.A.2 Figures

Figure 1.A.1: Unanticipated tax changes



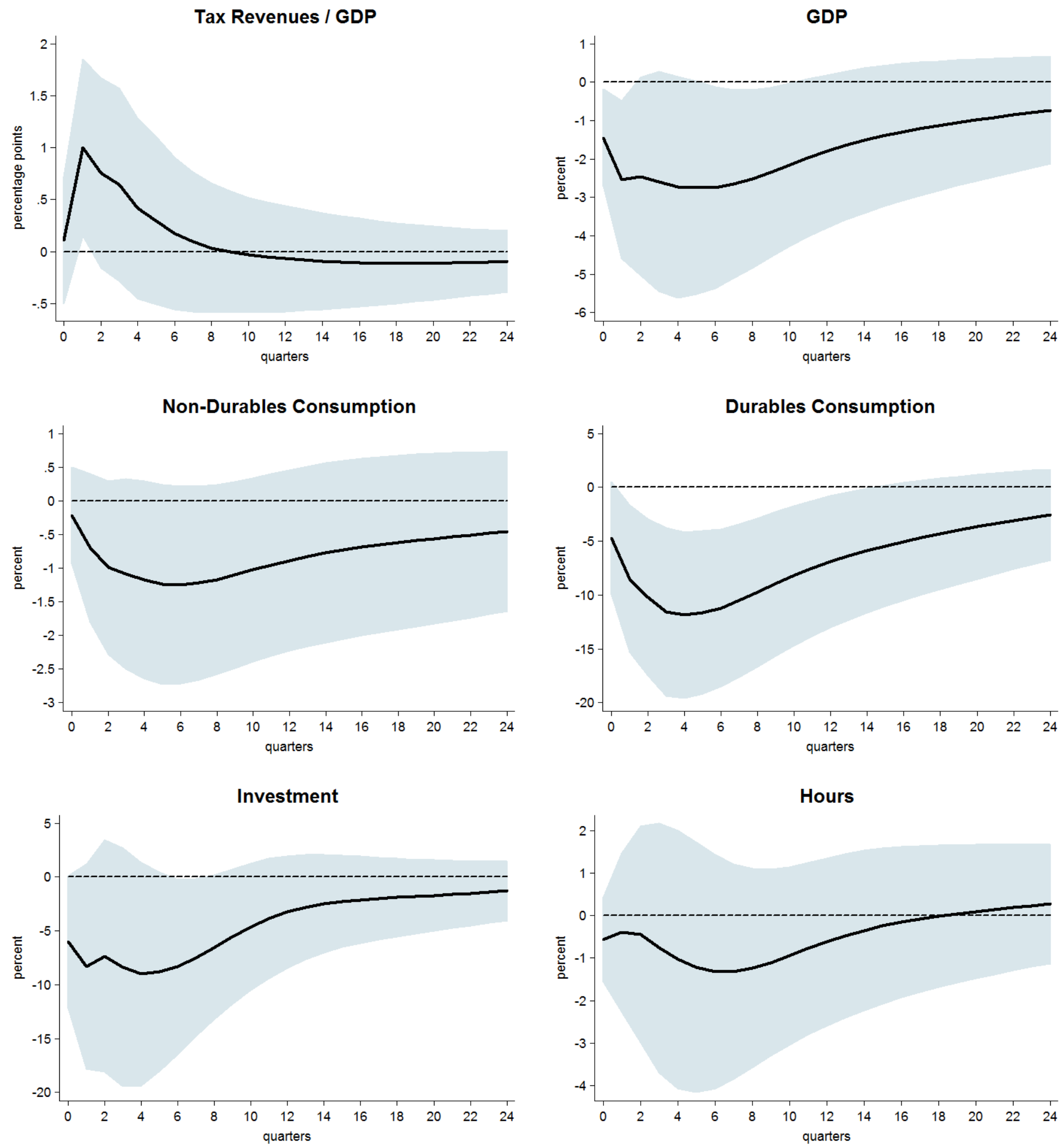
Notes: Unanticipated tax changes with a maximum implementation lag of 30 days. Tax changes are given in percent of GDP. Source: Own derivations based on Romer and Romer (2010), as described in Section 1.2.1.

Figure 1.A.2: Impulse responses of tax revenues/GDP



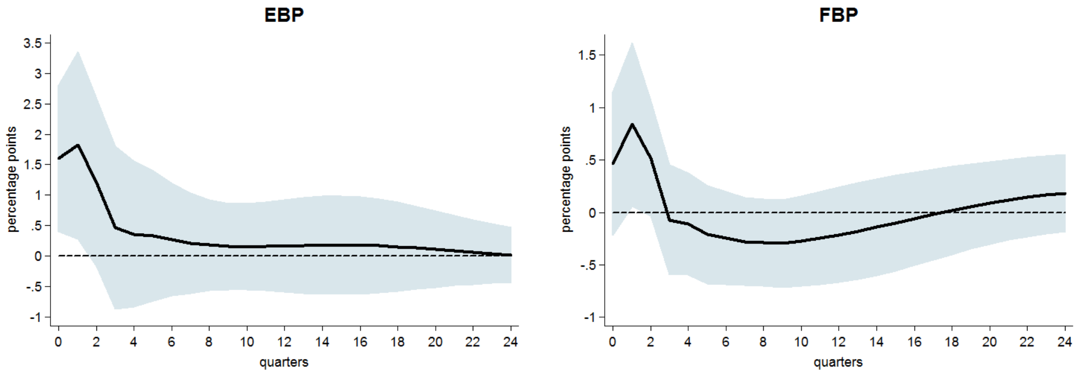
Notes: Impulse responses of tax revenues/GDP to a one percent increase in unanticipated taxes relative to nominal GDP with 95 percent confidence intervals. VAR using no exogenous lags (left panel) and one exogenous lag (right panel).

Figure 1.A.3: Impulse responses of endogenous variables



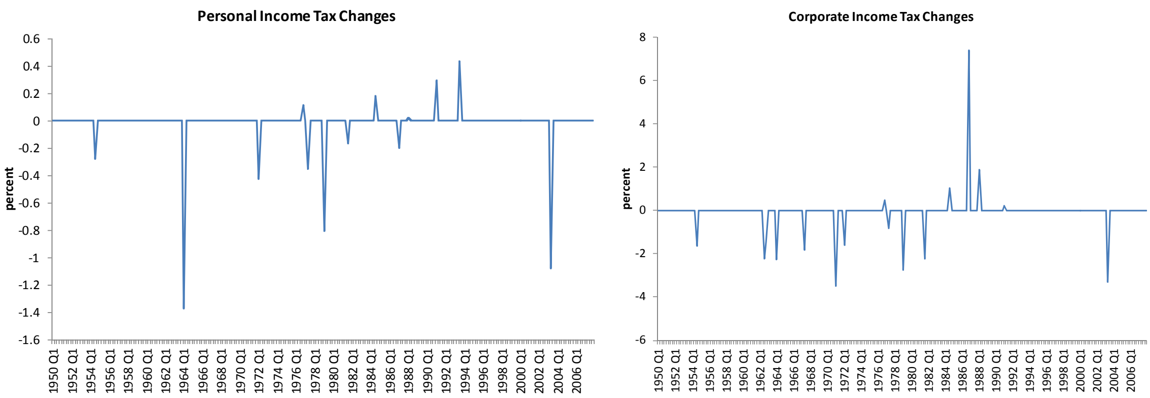
Notes: Impulse responses to a one percent increase in unanticipated taxes relative to nominal GDP with 95 percent confidence intervals.

Figure 1.A.4: Impulse responses of EBP and FBP



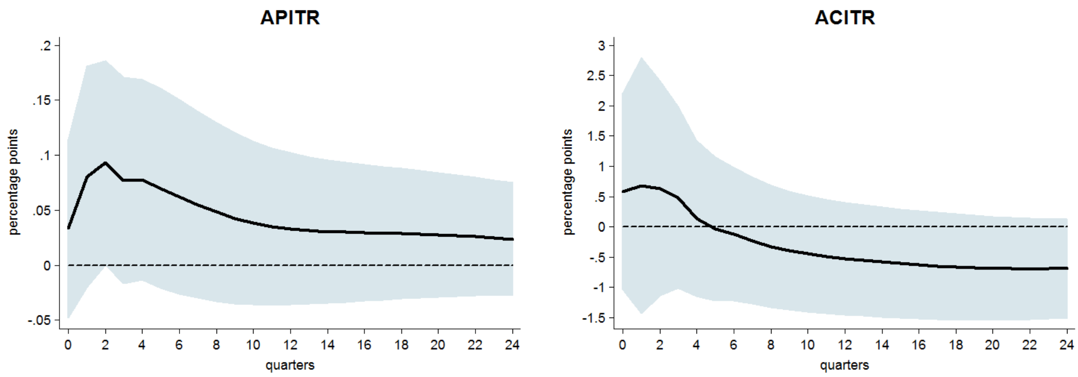
Notes: Impulse responses of excess bond premia for non-financial (left panel) and financial (right panel) firms to a one percent increase in unanticipated taxes relative to nominal GDP with 95 percent confidence intervals.

Figure 1.A.5: Personal and corporate income tax changes



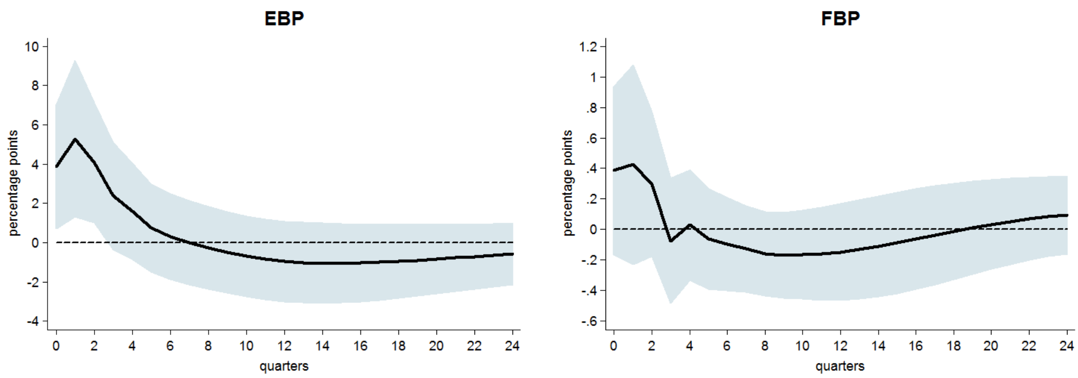
Notes: Personal income tax changes are given in percent of personal taxable income (left panel) and corporate income tax changes are given in percent of corporate profits (right panel). Source: Mertens and Ravn (2013).

Figure 1.A.6: Impulse responses of APITR and ACITR



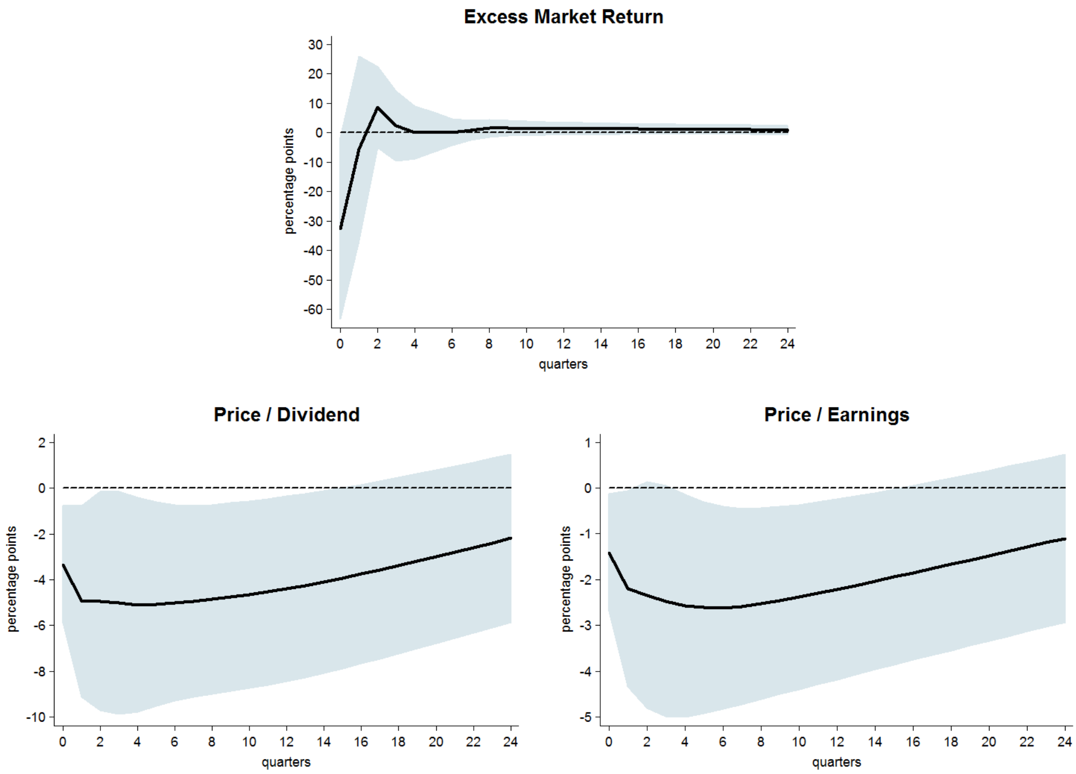
Notes: Cross-responses of the average personal income tax rate (APITR) and the average corporate income tax rate (ACITR) to a one percent increase in corporate and personal income taxes respectively with 95 percent confidence intervals.

Figure 1.A.7: Impulse responses of EBP and FBP



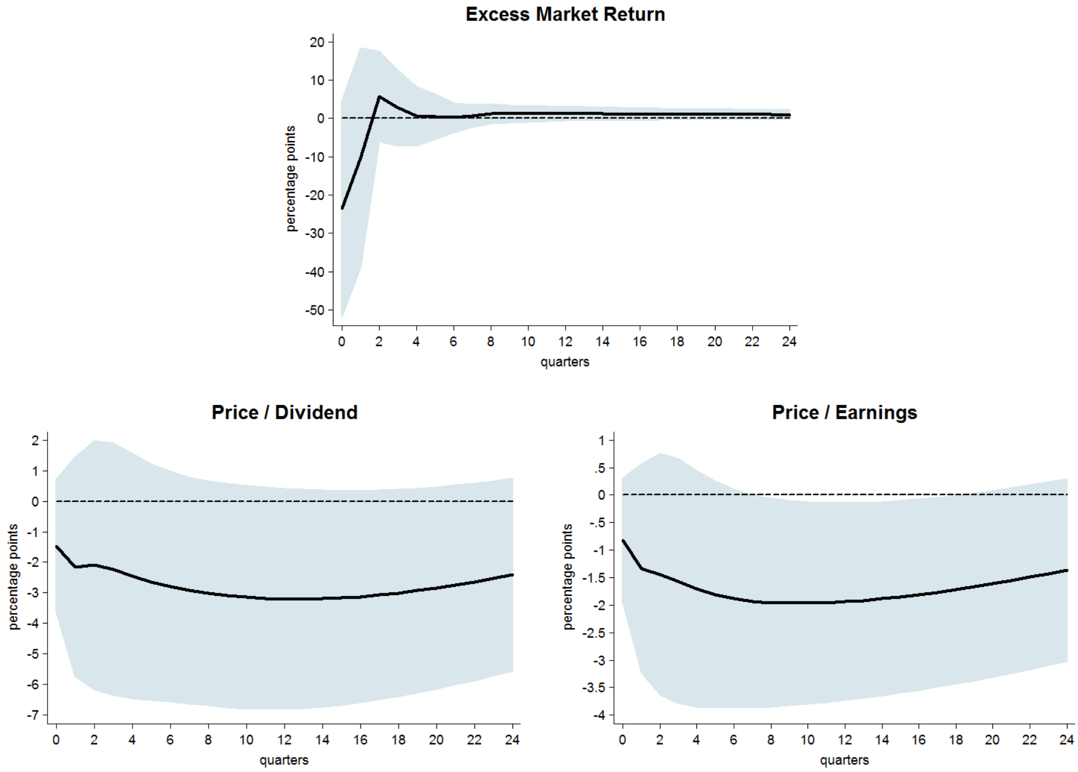
Notes: Impulse responses of excess bond premia for non-financial (left panel) and financial (right panel) firms to a one percent increase in personal income taxes with 95 percent confidence intervals.

Figure 1.A.8: Impulse responses of stock market variables



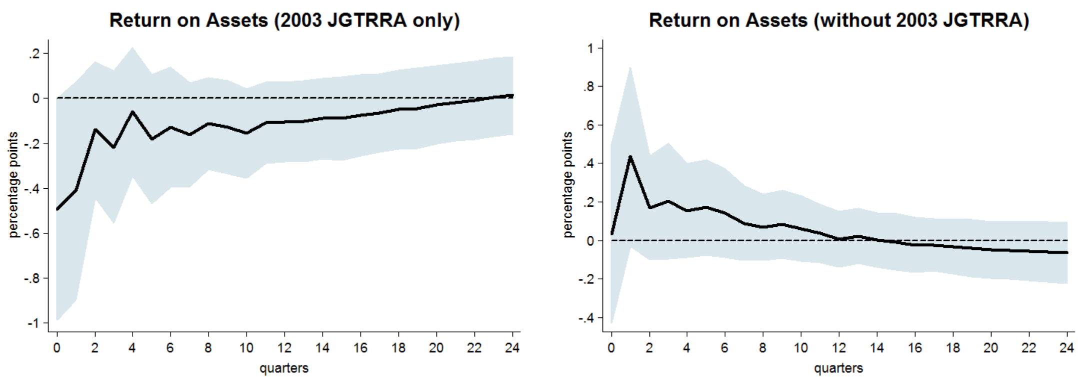
Notes: Impulse responses to a one percent increase in personal income taxes with 90 percent (EMR) and 95 percent confidence intervals.

Figure 1.A.9: Impulse responses of stock market variables without 2003 JGTRRA



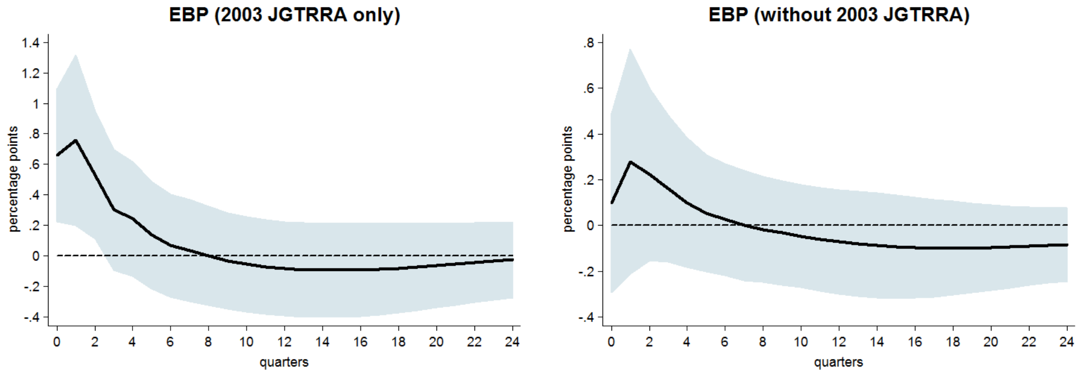
Notes: Impulse responses to a one percent increase in personal income taxes excluding the 2003 JGTRRA with 90 percent (EMR) and 95 percent confidence intervals.

Figure 1.A.10: Impulse responses of the return on assets of the aggregate financial sector



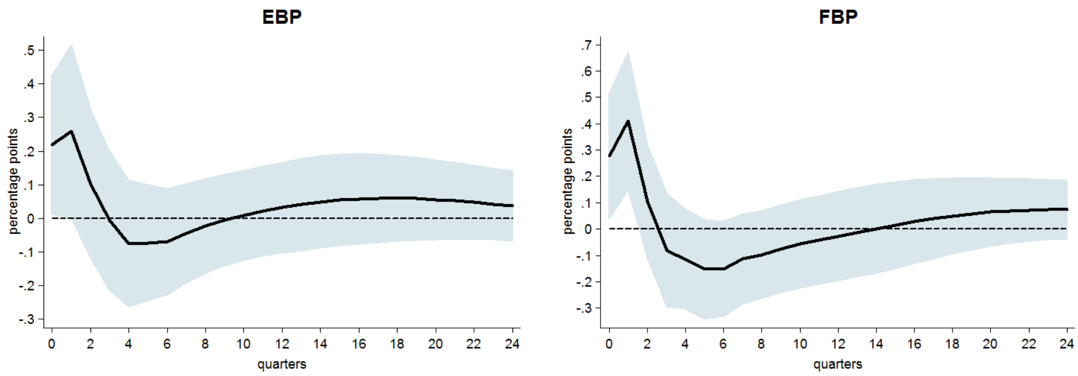
Notes: Impulse responses to the 2003 JGTRRA (left panel) and to personal income taxes excluding the 2003 JGTRRA (right panel) with 95 percent confidence intervals.

Figure 1.A.11: Impulse responses of EBP



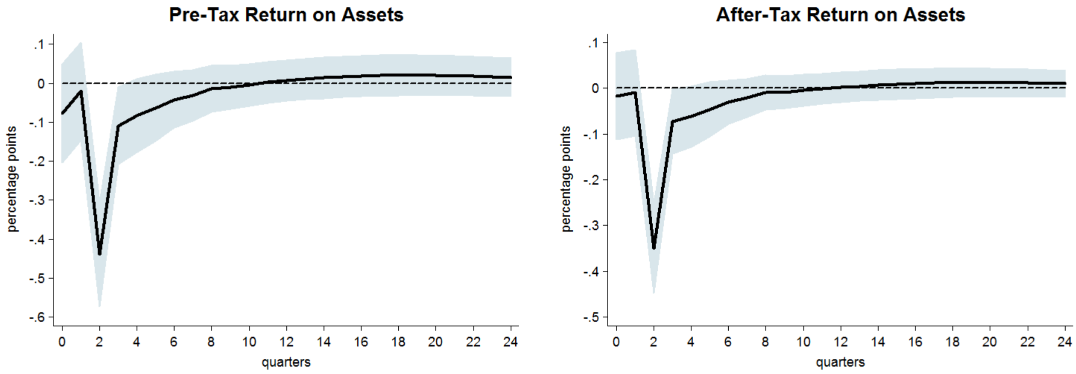
Notes: Impulse responses of the excess bond premium for non-financial firms to the 2003 JGTRRA (left panel) and to personal income taxes excluding the 2003 JGTRRA (right panel) with 95 percent confidence intervals.

Figure 1.A.12: Impulse responses of EBP and FBP



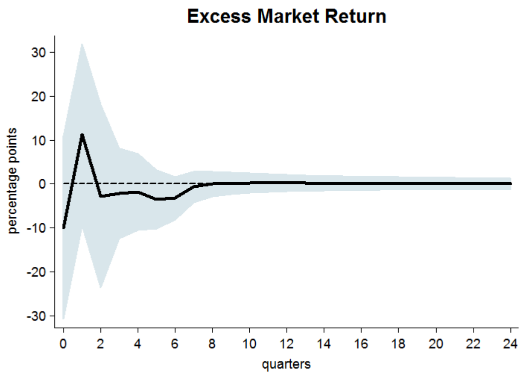
Notes: Impulse responses of excess bond premia for non-financial (left panel) and financial (right panel) firms to a one percent increase in corporate income taxes with 95 percent confidence interval.

Figure 1.A.13: Impulse responses of the return on assets of commercial banks



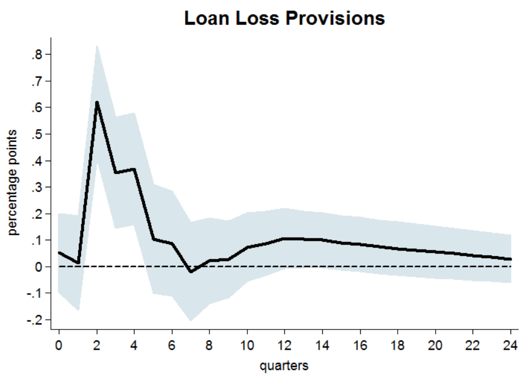
Notes: Impulse responses to a one percent increase in corporate income taxes with 95 percent confidence intervals.

Figure 1.A.14: Impulse response of the excess stock market return



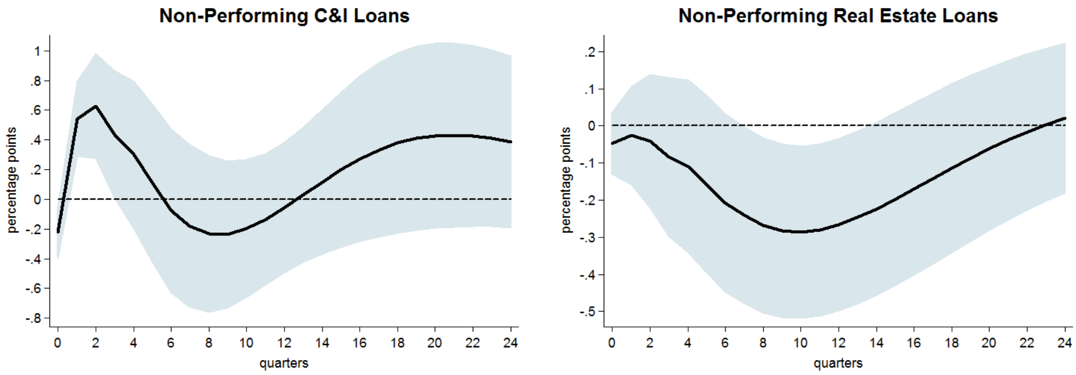
Notes: Impulse response to a one percent increase in corporate income taxes with 95 percent confidence interval.

Figure 1.A.15: Impulse response of the share of loan loss provisions



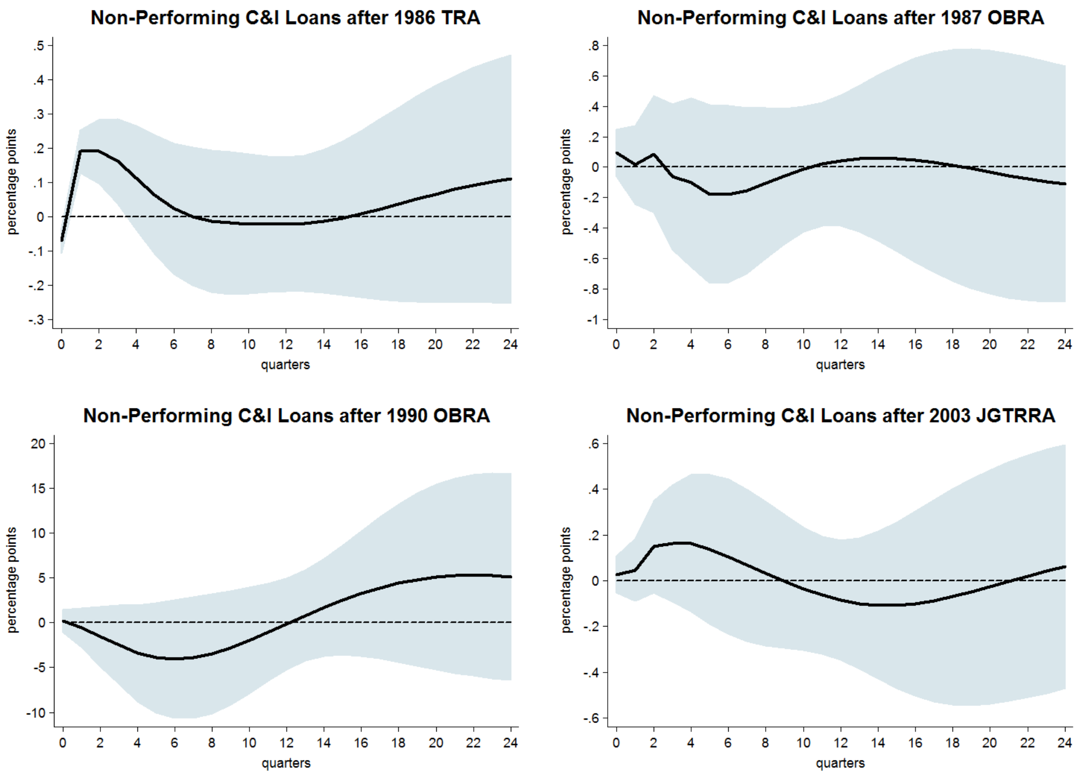
Notes: Impulse response to a one percent increase in corporate income taxes with 95 percent confidence interval.

Figure 1.A.16: Impulse responses of the share of non-performing loans



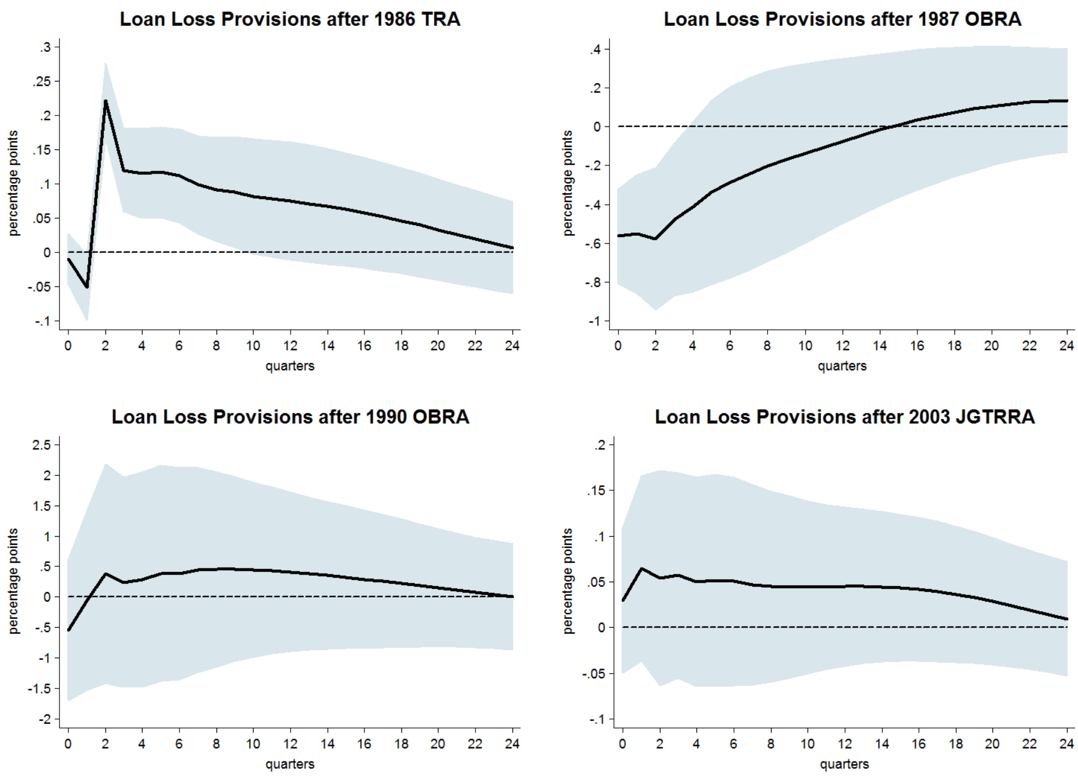
Notes: Impulse responses to a one percent increase in corporate income taxes with 95 percent confidence intervals.

Figure 1.A.17: Impulse responses of the share of non-performing C&I loans



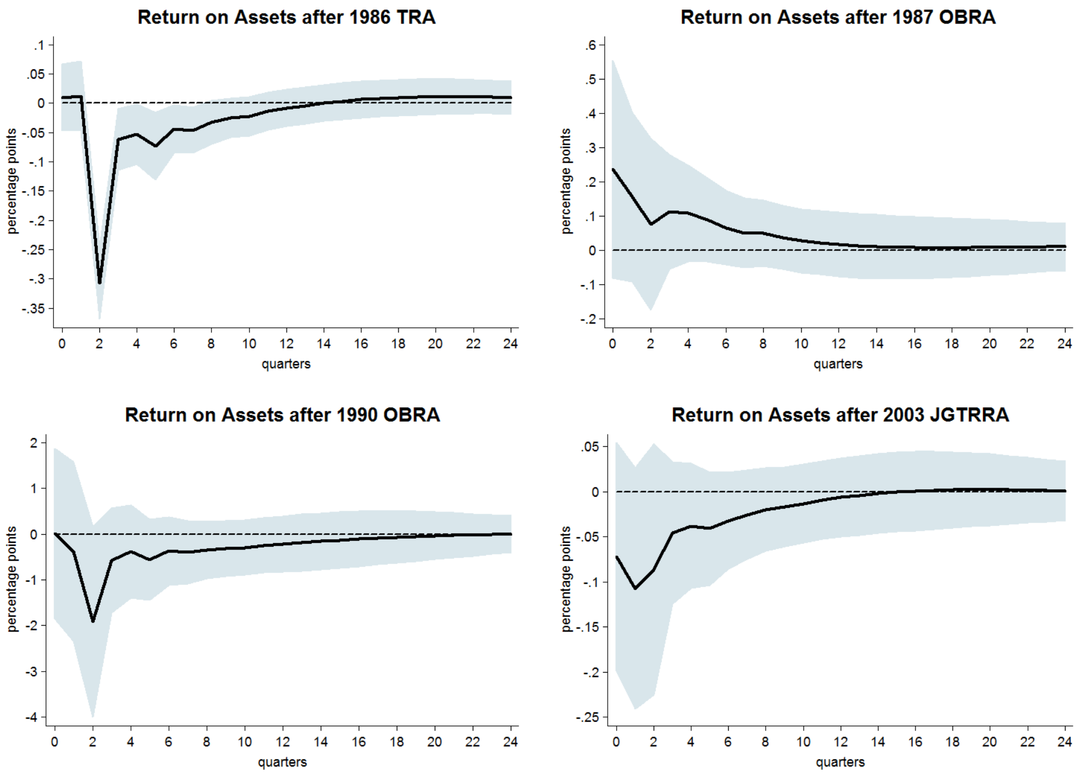
Notes: Impulse responses to the corporate income tax component of specific tax acts with 95 percent confidence intervals. Results based on dummy variable approach.

Figure 1.A.18: Impulse responses of the share of loan loss provisions



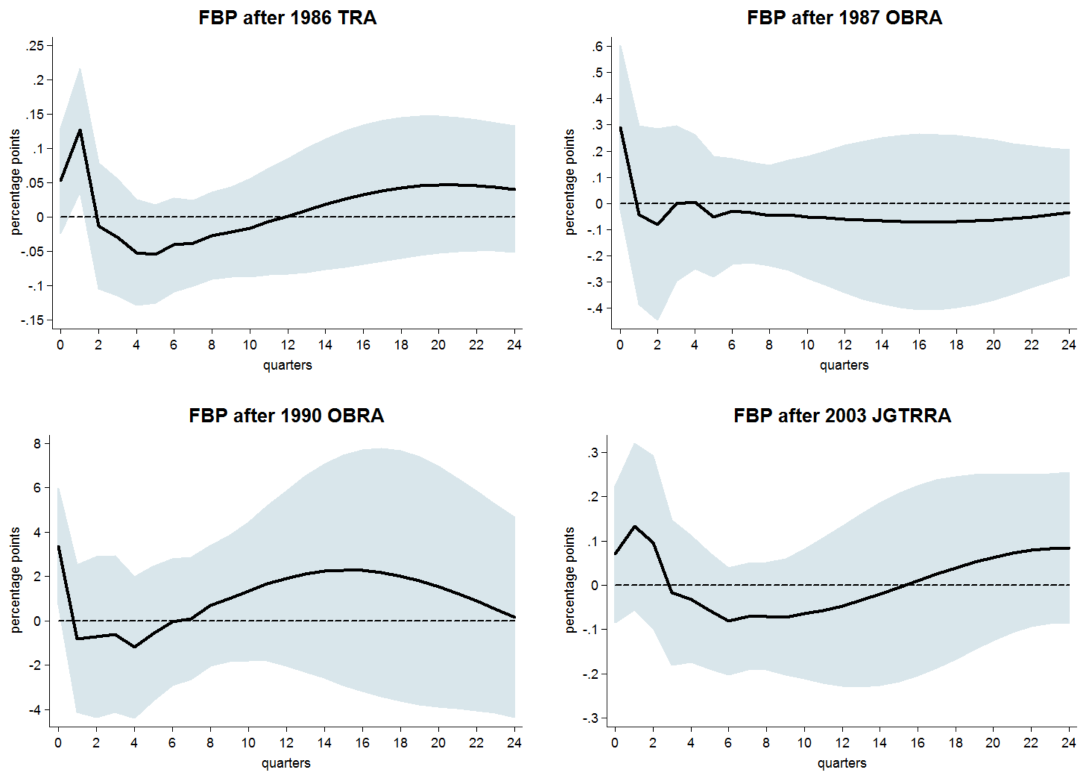
Notes: Impulse responses to the corporate income tax component of specific tax acts with 95 percent confidence intervals. Results based on dummy variable approach.

Figure 1.A.19: Impulse responses of the return on assets of commercial banks



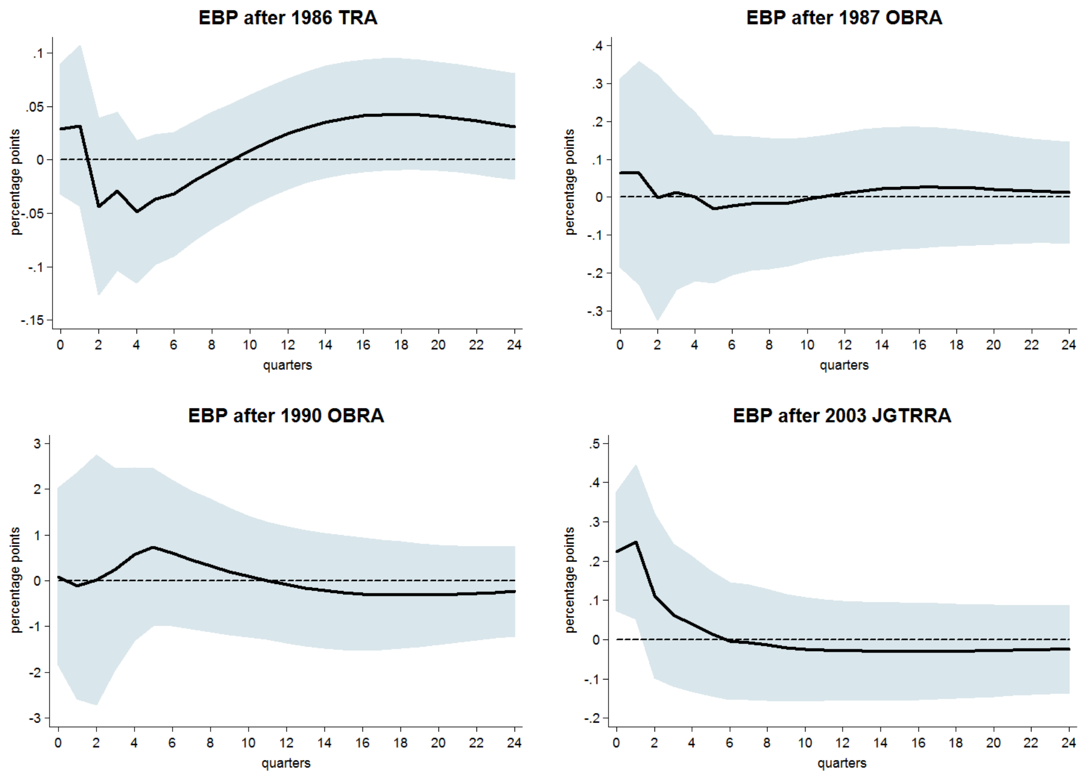
Notes: Impulse responses to the corporate income tax component of specific tax acts with 95 percent confidence intervals. Results based on dummy variable approach.

Figure 1.A.20: Impulse responses of FBP



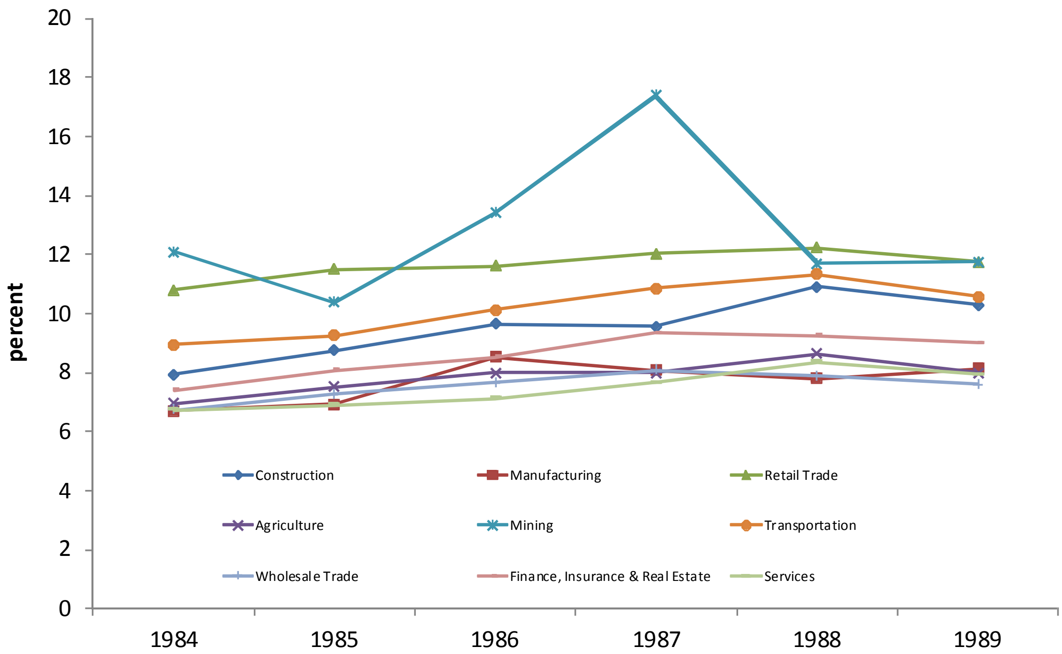
Notes: Impulse responses of the excess bond premium for financial firms to the corporate income tax component of specific tax acts with 95 percent confidence intervals. Results based on dummy variable approach.

Figure 1.A.21: Impulse responses of EBP



Notes: Impulse responses of the excess bond premium for non-financial firms to the corporate income tax component of specific tax acts with 95 percent confidence intervals. Results based on dummy variable approach.

Figure 1.A.22: Failure rates of firms



Notes: Failure rates of firms in different sectors. Source: Own calculations based on Business Dynamics Survey.

2 The Importance of Investment Wedges for the Transmission of Tax Changes

Joint with Christoph Winter

2.1 Introduction

In the first paper of this thesis, we have shown empirically that taxes have an impact on credit market conditions. In the present paper, we take a theoretical approach and demonstrate that investment wedges, which can be caused by financial frictions, are also important for the modeling of the transmission of tax changes.

The starting point for our second paper is the fact that empirically, tax changes have substantial effects on real economic activity, as has been widely documented by the previous literature.[1] Tax multipliers are especially large for durables purchases and investment, which suggests that these two variables are the driving forces behind the contractionary effect of tax changes on the economy as a whole.[2] It is therefore crucial to understand why they react to tax changes in such a strong way. Previous research has shown that existing models for the transmission of tax changes have difficulties explaining the large tax multipliers of durables purchases and investment.[3]

The goal of our paper is to quantify the additional investment wedges needed on top of standard tax distortions in order to explain the large tax multipliers for durables purchases and investment that we observe in the data. As a measurement tool, we use an augmented RBC model. We argue that any model that wants to successfully account for the transmission of tax changes needs to be consistent with the additional investment wedges implied by our exercise. As a second contribution, we discuss possible microfoundations that can endogenously generate these additional investment wedges. We argue that financial frictions are obvious candidates. Thus, our results provide important guidance for the modeling of the transmission of tax changes and for the modeling of financial frictions.

[1] See e.g. Blanchard and Perotti (2002), Romer and Romer (2010), and Mertens and Ravn (2011, 2012, 2013, 2014).

[2] See e.g. Romer and Romer (2010) and Blanchard and Perotti (2002).

[3] See e.g. Romer and Romer (2010), Mertens and Ravn (2011), and Zubairy (2014).

Our paper is divided into three parts. In the first part, we empirically document that an increase in tax liabilities by one percent of GDP decreases investment and durables purchases by more than seven percent. We do so by replicating the results by Mertens and Ravn (2011), who identify exogenous tax liability changes in the US using the narrative approach by Romer and Romer (2010). More generally, large tax multipliers for private investment are a robust feature of the data and are independent of the identification scheme used.[4]

In the second part of our paper, we analyze to what extent distortions that are caused by an increase in the labor and capital income tax can generate the empirically observable tax multipliers. To this end, we estimate the processes of labor and capital income taxes in an RBC model that we augment by real rigidities such as adjustment costs, varying capital utilization, and habits, as in Mertens and Ravn (2011). We discipline the response of taxes by imposing that tax liabilities increase by one percent of GDP, as in the data. Our results suggest that the implied distortions are too weak and are not able to account for the large empirical tax multipliers. This is a common finding in the literature, see e.g. Romer and Romer (2010), Mertens and Ravn (2011), and Zubairy (2014). Our estimates reveal that additional investment wedges are necessary in order to generate the empirically documented responses of investment and durables purchases. Specifically, our results suggest that separate wedges for durables and capital investment are needed in order to match the data. Furthermore, both additional wedges should be positively affected by tax changes.

In summary, we demonstrate that a model that successfully accounts for the empirical response of investment and durables purchases to tax changes requires two additional investment wedges on top of the standard tax distortions. In doing so, we contribute to the literature that models the transmission of taxes, such as Baxter and King (1993), McGrattan (1994), Braun (1994), and Mertens and Ravn (2011). In our model, we do not take a stand on the microfoundations of these additional investment wedges. Instead, we follow Chari, Kehoe, and McGrattan (2007), who demonstrate that the effect of distortions in a variety of models can be replicated by introducing time-varying wedges into an otherwise standard neoclassical growth model. Whereas they argue that investment wedges are not key in order to explain business cycles, we show that these wedges are crucial for the modeling of the transmission of tax changes.

In the third part of our paper, we discuss possible microfoundations that are able to generate investment wedges endogenously. We argue that financial frictions are obvious candidates because they can give rise to investment wedges such as e.g. spreads between borrowing and lending rates or borrowing constraints. We show that credit spreads in the

[4]See Ramey (2015) for a recent overview of the empirical literature on the estimation of tax multipliers.

data also react to tax changes.

Under the assumption that investment wedges are generated by financial frictions, our results provide guidance on how these frictions should be modeled. This is an important contribution, given the diversity of modeling approaches (see e.g. Gertler and Kiyotaki 2010 and Quadrini 2011 for recent surveys). As a consequence, tax changes can affect financial frictions through a host of potential channels. Based on our findings, we conclude that the right model should have a channel that induces a positive comovement between investment wedges and tax changes and should generate a response in the wedges for both capital and durables investment. In this context, we discuss several alternative modeling approaches.

A prominent strand of the literature models financial frictions as an agency problem at the level of entrepreneurs, see e.g. Bernanke and Gertler (1995), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (1999). This approach cannot explain investment wedges for durables because, by definition, these goods are purchased by households.[5] Moreover, in all of these models, the intensity of the financial friction is inversely related to the net worth of entrepreneurs. However, depending on the specific model environment and tax instrument considered, the net worth position may actually improve after a tax increase, as demonstrated by Fernández-Villaverde (2010) and Strulik (2008).[6] Thus, these models may generate a negative comovement between tax changes and investment wedges, which is inconsistent with our results.

We conclude that our findings support recent theories of financial frictions that operate at the level of financial intermediaries, such as e.g. Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Gertler, Kiyotaki, and Queralto (2012), He and Krishnamurthy (2013), and Brunnermeier and Sannikov (2014). In these models, the intensity of the friction is related to the net worth of financial intermediaries. Under the assumption that both firms and households borrow from the intermediary, these models can generate wedges for both durables and capital investment. As long as a tax increase reduces the intermediaries' net worth, these models may furthermore be able to predict the positive comovement between taxes and investment wedges implied by our results.

The remainder of this paper is structured as follows. Section 2.2 derives empirical impulse responses of economic variables to a tax shock. Section 2.3 describes the model, which is estimated in Section 2.4. The results from our impulse response matching exercise

[5]According to the NIPA definition, durables consumption is part of personal consumption, which is purchased by households and nonprofit institutions serving households.

[6]In Fernández-Villaverde (2010), higher taxes imply higher inflation, which increases net worth and thus decreases interest rate spreads. The model by Strulik (2008) predicts a lower risk premium after an increase in private capital income taxes because the firms' equity is worth more compared to (taxed) debt finance.

are presented in Section 2.5. In Section 2.6, we discuss the implications of our results. Section 2.7 concludes.

2.2 Empirical Estimation

In this section, we empirically estimate the effect of tax changes on real economic activity. For this purpose, we replicate the results by Mertens and Ravn (2011). In the following, we provide a broad overview of their estimation strategy.

Exogenous tax changes are identified using the narrative approach by Romer and Romer (2010). Mertens and Ravn (2011) furthermore divide the resulting dataset into anticipated and unanticipated tax changes. A tax act is classified as anticipated if the time span between its announcement and implementation date is longer than 90 days. This results in 36 anticipated and 34 unanticipated tax changes. Based on these data, they specify the following VAR model:

$$X_t = A + Bt + C(L)X_{t-1} + D(L)\tau_t^u + F(L)\tau_{t,0}^a + \sum_{i=1}^{K} G_i \tau_{t,i}^a + e_t \tag{2.1}$$

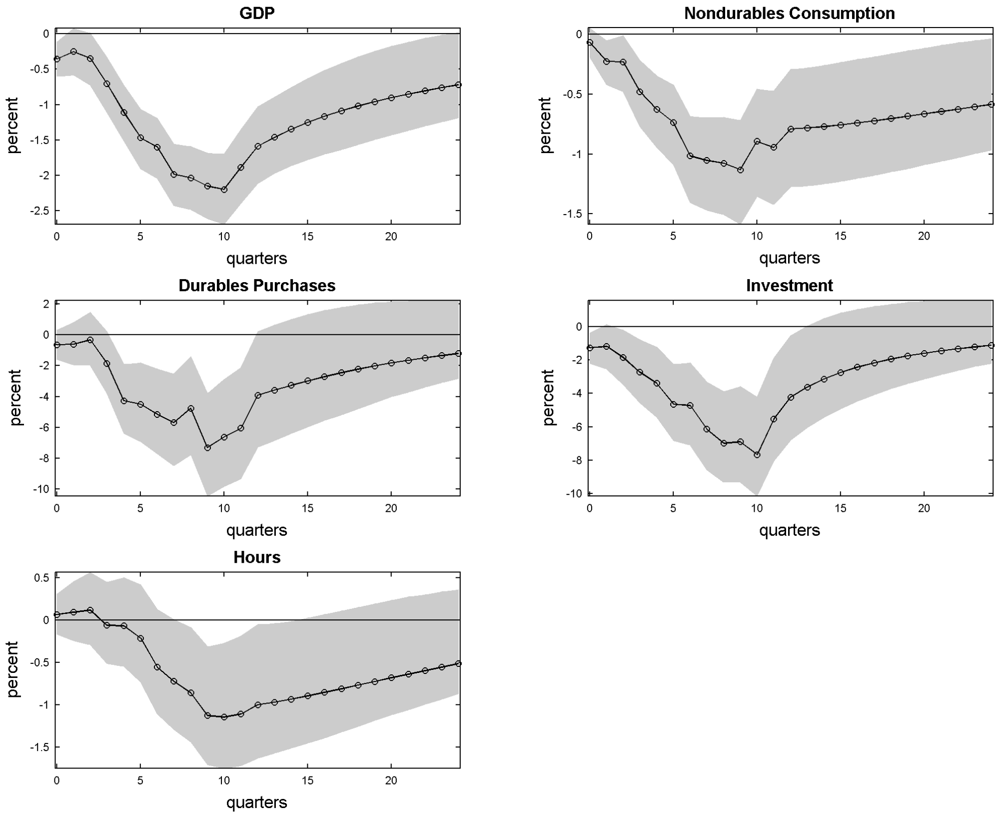
where X_t is a vector of endogenous variables, whose responses are characterized by a lag polynomial of order P, referred to as $C(L)$. Tax changes, on the other hand, enter the VAR as exogenous variables. Unanticipated tax changes are denoted by τ_t^u. Anticipated tax changes, $\tau_{t,i}^a$, are included in the VAR as soon as they are announced, with a maximum implementation lag of 16 quarters. Within this time span, any tax change that is known in time t and that is going to be implemented in time $t+i$ is used as a control variable. The coefficients on unanticipated and implemented anticipated tax changes are represented by $D(L)$ and $F(L)$, which are lag polynomials of order $R+1$. A is a constant and B is the coefficient on a linear time trend. Following Mertens and Ravn (2011), we use one endogenous and twelve exogenous lags, i.e. $P = 1$ and $R = 12$.

Our variables of interest are collected in the vector of endogenous variables, which consists of real GDP, real consumption of nondurable goods and services, real expenditures on durable goods, real private and government investment, and hours worked. All variables are divided by population and thus are in per capita terms. We use the data by Mertens and Ravn (2011), who retrieve them from the Bureau of Economic Analysis.[7] All endogenous variables enter the VAR in Equation (2.1) in logarithms.

In this paper, we are interested in the effect of an unanticipated tax increase on our endogenous variables. Therefore, anticipated tax changes only act as control variables

[7] Hours worked are partly obtained from Francis and Ramey (2004).

Figure 2.1: Impulse responses to an unanticipated tax increase



Notes: Empirical impulse responses after an increase in unanticipated taxes by one percent of GDP. Estimates from a VAR with one endogenous and twelve exogenous lags. Shaded areas correspond to 68 percent confidence intervals.

and are not affected by the shock. Figure 2.1 presents the impulse responses to a tax increase by one percent of GDP for the first 24 quarters after the shock. Shaded areas correspond to 68 percent confidence intervals, which are computed using a bootstrap with 10'000 replications. We find tax multipliers at the peak of 2.2 percent for GDP, 1.1 percent for nondurables consumption, and 1.2 percent for hours worked. The multipliers for durables purchases and investment are especially large. They amount to 7.3 percent and 7.7 percent respectively.

As mentioned above, our results are based on the narrative approach by Romer and Romer (2010), which has also been used by Favero and Giavazzi (2012) and Mertens and Ravn (2011, 2012, 2013, 2014). Alternatively, Mountford and Uhlig (2009) use sign restrictions in a VAR and find even larger tax multipliers. Another prominent method identifies tax shocks in a structural VAR. This approach was first applied by Blanchard and Perotti (2002). In line with our findings, they also document a highly significant reaction of investment to tax changes. However, their multipliers are quantitatively not comparable to ours because their results hinge on an inappropriate assumption about the elasticity of tax revenues to GDP. As demonstrated by Caldara and Kamps (2012), the estimates by Blanchard and Perotti (2002) are sensitive to small changes in this elasticity.[8] According to Mertens and Ravn (2014), the true output elasticity of tax revenues is higher than originally assumed by Blanchard and Perotti (2002). With this new value, which is derived using the narrative tax series as an instrument in a structural VAR, Mertens and Ravn (2014) find tax multipliers that are in the same range as our results.

Based on these findings, we conclude that in the data, there is a strong reaction of economic variables to a tax change. The effect is especially pronounced for investment and durables purchases.[9] As documented above, these results are independent of the identification scheme used. In particular, Romer and Romer (2010) and Blanchard and Perotti (2002) both argue that the high response of investment is the driving force behind the tax multiplier for output.

In this paper, we demonstrate that an augmented version of the standard RBC model with tax wedges is not able to explain the large tax multipliers of investment and durables purchases. This is a common finding in the literature, see e.g. Romer and Romer (2010), Mertens and Ravn (2011), and Zubairy (2014).[10] The goal of our paper is to quantify the additional investment wedges needed in order to match the empirical responses of investment and durables purchases to a tax change.

2.3 Model

The aim of this section is to develop a model of distortionary taxation that can explain the large tax multipliers documented in our empirical estimation. In order to do so, we start from classical models such as McGrattan (1994), Braun (1994), and Baxter and King (1993), and additionally incorporate several features that have been shown to be relevant for the transmission of tax changes to real economic activity. In particular, we allow for habit formation, investment and durables adjustment costs, and varying

[8] Note that Perotti (2012) points out that there is an additional bias in the tax multipliers calculated by Blanchard and Perotti (2002). He argues that their estimates are biased towards zero because they do not take into account that the discretionary and endogenous component of a tax change may affect economic variables in a different way.

[9] Romer and Romer (2010) show that the high multiplier on investment is not driven by those tax acts that change investment incentives. In fact, when they exclude these tax changes from their sample, the estimated response of investment becomes even higher.

[10] The paper by Romer and Romer (2010) is purely empirical. However, they argue that the high investment multipliers found in their analysis cannot be explained by interest rate effects in conventional models. Furthermore, note that Zubairy (2014) does not include durables purchases in her estimation and therefore, she does not provide tax multipliers for this variable.

capital utilization, as e.g. in Auerbach (1986), Burnside, Eichenbaum, and Fisher (2004), Christiano, Motto, and Rostagno (2010), and Mertens and Ravn (2011).

Using this model, we show that standard tax wedges are not able to account for the large empirical tax multipliers of durables purchases and investment documented in the previous section. Therefore, we introduce two additional investment wedges in our model. In our estimation, we then quantify the size of these additional investment distortions that are needed in order to match the empirical tax multipliers of durables purchases and investment. Our findings provide helpful guidance for the construction of models that successfully explain the transmission of taxes.

Following Hall (2011), we model our additional investment wedges as a wedge between borrowing and lending rates for capital and durables investment. The advantage of this approach is that it allows us to introduce separate investment wedges for capital and durable goods. In the following, we refer to these additional investment wedges as 'frictions'. This notation is inspired by Hall (2011), who interprets this type of wedges as financial frictions. In Section 2.6, we discuss whether this interpretation is appropriate in our context.

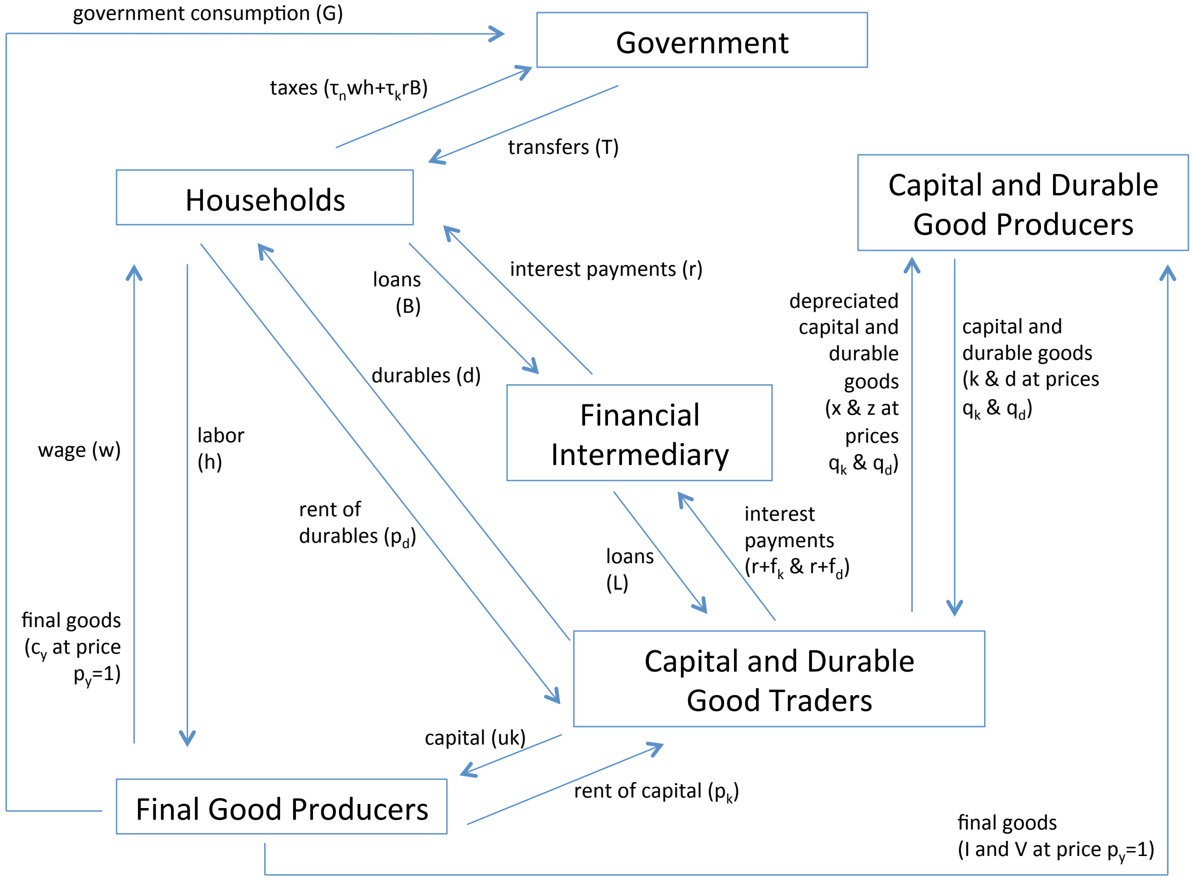
In the language of Chari, Kehoe, and McGrattan (2007), our model thus gives rise to four wedges, with each of them affecting a different set of equilibrium conditions. The capital income tax distorts the households' intertemporal Euler equation and can therefore be interpreted as an investment wedge. Labor income taxes, on the other hand, affect the (intratemporal) labor supply decision by households. Accordingly, Chari, Kehoe, and McGrattan (2007) call them labor wedges. Our two additional frictions furthermore drive a wedge between the interest rate paid by capital and durables investors and the return received by households on their savings. Using the notation by Chari, Kehoe, and McGrattan (2007), these two frictions therefore correspond to investment wedges.

Note that we refer to wedges that distort intertemporal equilibrium conditions, such as the Euler equation, as intertemporal wedges. Wedges that affect static optimality conditions, such as the labor-leisure choice, are called intratemporal wedges.

2.3.1 Overview of the Model

In order to model borrowing and lending rates explicitly, we need to depart from the standard RBC framework in which the representative household owns all the capital of the economy. We do so by introducing capital and durable good traders, who take out loans to buy capital and durables, which they then rent to final good producers and to the household. Two additional investment wedges cause the lending rate paid by traders to be higher than the borrowing rate faced by the household. The resulting interest rate spread is allowed to differ for capital and durable good traders.

Figure 2.2: Interaction of agents in the model

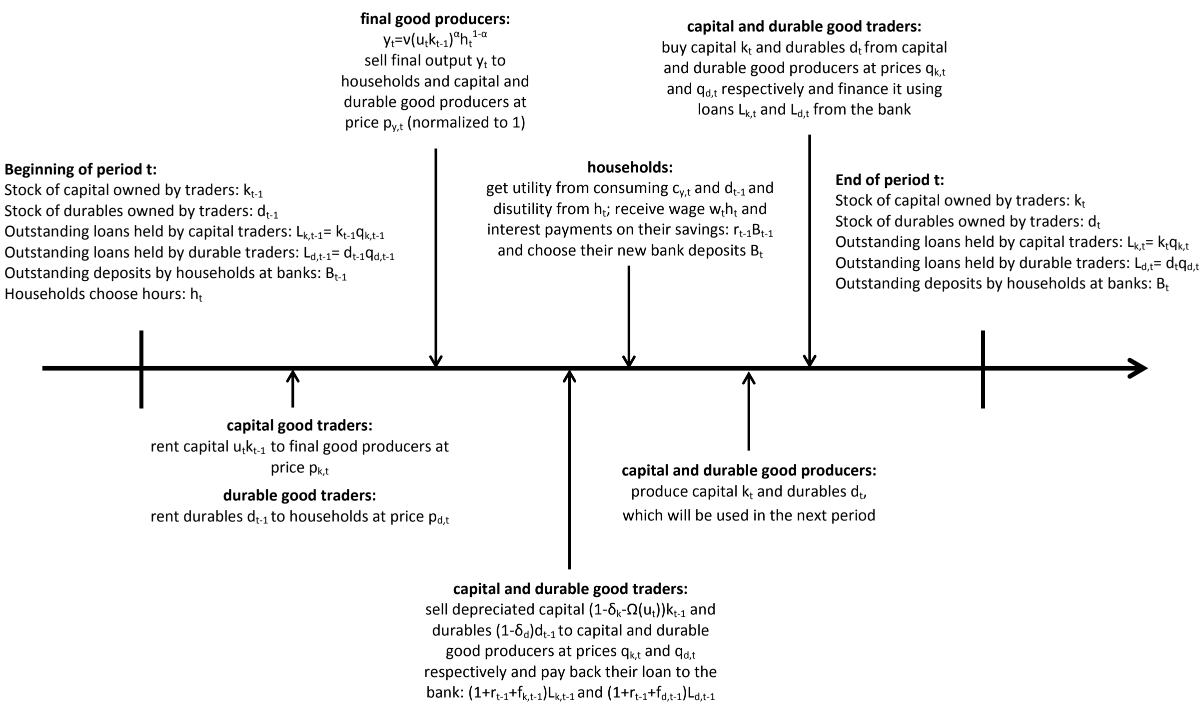


Accordingly, there are six agents in our model. A representative household consumes durable and final goods. It supplies labor to final good producers and pays taxes on its capital and wage income to the government. The durable goods consumed by the household are produced by durable good producers. They transform final output into new durable goods and combine them with depreciated durables from the previous period. Capital is produced by capital good producers in an analogous manner, reusing old capital and producing new capital using final output. Capital and durable goods are then sold to capital and durable good traders, who rent durables to the household and capital to final good producers. Traders borrow from the financial intermediary in order to purchase capital and durables, which are later sold back to the producers. The financial intermediary stands between the household, who acts as a lender, and traders. Investment wedges cause the interest rate paid by traders to be higher than the interest rate received by the household. Furthermore, the government raises a tax on returns to saving and labor income. It uses the income from the household's tax payments in order to finance its own consumption, which is exogenously given and constant over time. The government budget constraint is balanced by lump-sum transfers to or from the household. Figure 2.2 provides an overview of the interaction between all the agents in our model.

2.3.2 Model Details

The following subsection describes every agent's problem and optimality conditions. A full list of all equations used in our estimation is provided in Section 2.A.1 in the Appendix. For the sake of clarity, we apply a timing convention in which every variable carries the time subscript of the period in which it is determined.[11] The exact timing of our model is summarized in Figure 2.3.

Figure 2.3: Timing of the model



The Representative Household

The infinitely lived representative household gets utility from consuming a composite consumption good c, consisting of final goods c_y and durable goods d. Furthermore, it gets disutility from supplying labor h to final good producers at a wage w. The final good consumed by the household is produced by final good producers and its price is

[11]State variables therefore usually have a time subscript $t-1$, whereas control variables are determined contemporaneously and therefore carry a time subscript t.

normalized to one. Durables are rented to the household by durable good traders at price p_d.

The household can acquire bonds B that pay an interest rate r. The return on these bonds as well as the household's labor income are taxed at rates τ_k and τ_n respectively. In the following, we will refer to τ_k as the capital tax and to τ_n as the labor income tax. The labor tax gives rise to an intratemporal wedge in the household's problem, whereas the capital tax creates an intertemporal wedge. In addition, the household receives lump-sum transfers T from the government and F, which denotes the loss that arises due to our additional investment frictions. Given that we are interested in the distortion caused by the friction and not in its income effect, this technicality ensures that we can quantitatively compare the model with frictions to a model that only contains tax wedges. The definition and timing of F are described in more detail later in this section.

The household's problem is given by:

$$\begin{aligned}
\max_{c_{y,t},d_{t-1},h_t,B_t} \quad & \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \gamma \frac{h_t^{1+\psi}}{1+\psi} \right) \\
s.t. \quad & B_t = B_{t-1} + (1-\tau_{n,t}) w_t h_t + (1-\tau_{k,t}) r_{t-1} B_{t-1} - c_{y,t} - p_{d,t} d_{t-1} + T_t + F_{t-1} \\
\& \quad & c_t = c_{y,t}^{\phi} d_{t-1}^{1-\phi} - \pi c_{y,t-1}^{\phi} d_{t-2}^{1-\phi}
\end{aligned}$$

The first constraint is the standard budget constraint and the second one is the definition of composite consumption, which features habit formation.

The optimality conditions of the representative household are listed in the following.

Euler equation:

$$[c_t^{-\sigma} - \beta\pi \mathbb{E}_t c_{t+1}^{-\sigma}] \left(\frac{d_{t-1}}{c_{y,t}} \right)^{1-\phi} = \beta \mathbb{E}_t [1 + (1-\tau_{k,t+1}) r_t][c_{t+1}^{-\sigma} - \beta\pi c_{t+2}^{-\sigma}] \left(\frac{d_t}{c_{y,t+1}} \right)^{1-\phi} \tag{2.2}$$

Labor-leisure choice:

$$[c_t^{-\sigma} - \beta\pi \mathbb{E}_t c_{t+1}^{-\sigma}] \phi \left(\frac{d_{t-1}}{c_{y,t}} \right)^{1-\phi} = \frac{\gamma h_t^{\Psi}}{(1-\tau_{n,t}) w_t} \tag{2.3}$$

Choice of the optimal consumption mix:

$$\frac{\phi}{1-\phi} \frac{d_{t-1}}{c_{y,t}} p_{d,t} = 1 \tag{2.4}$$

It is important to note that it is essential for our analysis that we are able to distinguish between intra- and intertemporal wedges in order to quantify their relative importance. Thus, our capital tax wedge differs from other models in the sense that it only distorts intertemporal decisions. In contrast, Mertens and Ravn (2011) e.g. levy a tax on utilized capital, which – in the language of Chari, Kehoe, and McGrattan (2007) – gives rise to an intratemporal efficiency wedge via utilization and an intertemporal investment wedge via capital.

Final Good Producers

Final good producers face a Cobb-Douglas production function that generates final goods y using labor h and (utilized) capital $\tilde{k}_t \equiv u_t k_{t-1}$. Capital $\tilde{k}$ is rented from capital good traders at a given utilization rate u at price p_k. The final good is then sold to the household for consumption and to capital and durable good producers, who use it in order to create new capital and durable goods for the next period.

The final good producers' problem is given by:[12]

$$\max_{\tilde{k}_t, h_t} \quad \nu \tilde{k}_t^{\alpha} h_t^{1-\alpha} - w_t h_t - \tilde{k}_t p_{k,t}$$

The optimality conditions of the final good producers read as:

$$p_{k,t} = \nu \alpha \tilde{k}_t^{\alpha-1} h_t^{1-\alpha} \tag{2.5}$$

and

$$w_t = \nu(1-\alpha)\tilde{k}_t^{\alpha} h_t^{-\alpha} \tag{2.6}$$

Capital and Durable Good Traders

Capital and durable good traders face a two-period problem. At the end of the first period, traders buy capital k and durable goods d from capital and durable good producers at prices q_k and q_d.[13] Capital and durable good traders do not have any net worth and therefore, they have to take out loans L_k and L_d in order to finance their purchases. Following Hall (2011), we assume that the total of capital and durable goods are debt

[12] Note that ν is just a scaling factor, which we use in order to normalize $y = 1$ in steady state. It does not change the model dynamics because it drops out in the log-linearization.

[13] q corresponds to Tobin's q and is defined as the ratio of the price of installed and uninstalled capital. Installed capital has already been produced (it is just the depreciated old capital), whereas uninstalled capital has not been produced yet (its price is the production cost of one unit of capital, which is the price of one unit of the final good in our economy and is normalized to $p_y = 1$).

financed. This is unlike the literature that usually assumes that entrepreneurs (who can be interpreted as traders in our framework) own wealth that can be used to finance investments, such as e.g. Bernanke, Gertler, and Gilchrist (1999). In contrast to their model, our setup allows us to interpret the spread between the borrowing and lending rate as an investment wedge because it ensures that it is always non-zero.[14]

At the beginning of the second period, capital good traders observe shocks to the economy and choose capital utilization u. They rent capital at this fixed utilization rate $\tilde{k} = uk$ to final good producers at price p_k. Durable good traders rent durable goods d to the household at price p_d.

At the end of the second period, traders sell the depreciated capital and durable goods back to capital and durable good producers at prices q_k and q_d respectively. They then pay back their loans, including interest payments. And this is where our two additional investment frictions play an important role. Capital good traders pay an interest rate $r + f_k$ and durable good traders pay $r + f_d$, whereas the household faces an interest rate r. Thus, f_k and f_d can be interpreted as capital and durables frictions that drive a wedge between the return on saving and the cost of borrowing.

At the beginning of period t, the problem of capital good traders is to choose capital utilization, taking the capital stock as given:

$$\max_{u_t} \quad p_{k,t}u_t k_{t-1} + (1 - \delta_k - \Omega(u_t))k_{t-1}q_{k,t} - (1 + r_{t-1} + f_{k,t-1})L_{k,t-1}$$

where δ_k is the depreciation rate of capital and $\Omega(u_t)$ is the utilization cost function. The first order condition with respect to u yields:

$$p_{k,t} = \Omega'(u_t)q_{k,t} \tag{2.7}$$

At the end of period t, the problem of capital good traders is to choose the amount of capital they want to buy from capital good producers, which also determines the size of the loan. Their problem is to maximize expected profits:

$$\begin{aligned} \max_{L_{k,t},k_t} \quad & \lambda_t \left[L_{k,t} - k_t q_{k,t}\right] \\ & + \mathbb{E}_t \beta \lambda_{t+1} \left[p_{k,t+1}u_{t+1}k_t + (1 - \delta_k - \Omega(u_{t+1}))k_t q_{k,t+1} - (1 + r_t + f_{k,t})L_{k,t}\right] \\ s.t \quad & k_t q_{k,t} \leq L_{k,t} \end{aligned}$$

where λ is the Lagrange multiplier from the household's problem. The constraint is

[14] If we want to interpret our investment wedges as financial frictions, our results should be seen as an upper bound for the importance of these frictions because in reality, entrepreneurs own positive net worth.

binding as long as $r_t + f_{k,t} > 0$, which is by definition always the case. Therefore, we can directly substitute $L_{k,t} = k_t q_{k,t}$ in the capital good traders' problem. This leaves us with the following optimization problem:

$$\max_{k_t} \quad \mathbb{E}_t \beta \lambda_{t+1} \left[p_{k,t+1} u_{t+1} k_t + (1 - \delta_k - \Omega(u_{t+1})) k_t q_{k,t+1} - (1 + r_t + f_{k,t}) k_t q_{k,t} \right]$$

From the first order condition with respect to capital, we can derive the rental price for capital:

$$\mathbb{E}_t p_{k,t+1} u_{t+1} = \mathbb{E}_t \left[(1 + r_t + f_{k,t}) q_{k,t} - (1 - \delta_k - \Omega(u_{t+1})) q_{k,t+1} \right] \tag{2.8}$$

By symmetry, we have the problem of the durable good traders (given $L_{d,t} = d_t q_{d,t}$):

$$\max_{d_t} \quad \mathbb{E}_t \beta \lambda_{t+1} \left[p_{d,t+1} d_t + (1 - \delta_d) d_t q_{d,t+1} - (1 + r_t + f_{d,t}) d_t q_{d,t} \right]$$

with solution:

$$\mathbb{E}_t p_{d,t+1} = \mathbb{E}_t \left[(1 + r_t + f_{d,t}) q_{d,t} - (1 - \delta_d) q_{d,t+1} \right] \tag{2.9}$$

Given the size of the loans by capital and durable good traders, the loss that arises due to our additional investment wedges compared to a frictionless economy is equal to:

$$F_t = f_{k,t} q_{k,t} k_t + f_{d,t} q_{d,t} d_t \tag{2.10}$$

F is given back to the household as a lump-sum transfer. This is necessary because when we compare different economies, we want to focus on the distortionary effect of the friction and not on its income effect. Note that the friction loss is already known in period t, but will only be paid in period $t+1$. Therefore, the lump-sum transfer F_t takes place in period $t+1$.

Capital and Durable Good Producers

Capital and durable good producers buy depreciated capital and durables (denoted by x and z respectively) back from traders after the final good production has taken place. In addition, they use their technology in order to transform the final good one-to-one into new units of capital and durables. When doing so, they pay capital and durable adjustment costs, determined by the functions $S_k\left(\frac{I_t}{I_{t-1}}\right)$ and $S_d\left(\frac{V_t}{V_{t-1}}\right)$, on the deviation of investment in the current period from the previous period. At the end of the period, capital and durable good producers combine the purchased (already installed) capital and durables with the newly produced units and sell them at price q_k and q_d to the traders.

The problem of the capital good producers is then given by:

$$\max_{x_t, I_t} \quad \mathbb{E}_t \sum_{i=0}^{\infty} \beta^i \lambda_{t+i} \mathcal{P}^k_{t+i}$$
$$where \quad \mathcal{P}^k_t = q_{k,t}\left[x_t + [1 - S_k\left(\frac{I_t}{I_{t-1}}\right)]I_t\right] - q_{k,t}x_t - I_t$$

λ is the Lagrange multiplier of the household's problem.

In a first step, capital good producers choose how much of the already installed (depreciated) capital x_t they want to buy. The corresponding first order condition is:

$$\frac{\partial \mathcal{P}^k_t}{\partial x_t} = q_{k,t} - q_{k,t} = 0$$

Therefore, any amount of x_t satisfies the optimality condition of the capital good producers. And it is also consistent with their optimality condition to buy all installed capital available in the economy:

$$x_t = (1 - \delta_k - \Omega(u_t))k_{t-1}$$

and thus:

$$k_t = (1 - \delta_k - \Omega(u_t))k_{t-1} + [1 - S_k\left(\frac{I_t}{I_{t-1}}\right)]I_t \tag{2.11}$$

By symmetry, it is optimal for durable good producers to buy all installed durables:

$$z_t = (1 - \delta_d)d_{t-1}$$

and thus:

$$d_t = (1 - \delta_d)d_{t-1} + [1 - S_d\left(\frac{V_t}{V_{t-1}}\right)]V_t \tag{2.12}$$

In a second step, capital good producers choose the level of investment in new capital I_t. This is a dynamic problem and the optimality condition reads as follows:

$$1 - q_{k,t}\left[1 - S_k\left(\frac{I_t}{I_{t-1}}\right) - S_k'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right] = \beta\mathbb{E}_t\frac{\lambda_{t+1}}{\lambda_t}q_{k,t+1}S_k'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2 \tag{2.13}$$

By symmetry, the optimality condition for investment in durable goods is given by:

$$1 - q_{d,t}\left[1 - S_d\left(\frac{V_t}{V_{t-1}}\right) - S_d'\left(\frac{V_t}{V_{t-1}}\right)\frac{V_t}{V_{t-1}}\right] = \beta\mathbb{E}_t\frac{\lambda_{t+1}}{\lambda_t}q_{d,t+1}S_d'\left(\frac{V_{t+1}}{V_t}\right)\left(\frac{V_{t+1}}{V_t}\right)^2 \tag{2.14}$$

Government

The government in our model is modeled in a very simple manner because we are not interested in an optimal taxation exercise. It consumes a constant amount G over time and finances this consumption using taxes on labor income, $\tau_{n,t}$, and on interest earnings on bonds, $\tau_{k,t}$. In order to balance the government's budget, we furthermore introduce lump-sum transfers T between the government and the household that can be either positive or negative. The government's budget constraint is:

$$G = \tau_{n,t} w_t h_t + \tau_{k,t} r_{t-1} B_{t-1} - T_t \tag{2.15}$$

where $G = g \cdot \bar{y}$, i.e. government consumption is a constant and time-invariant fraction of final output in steady state.

The Financial Intermediary

Following Hall (2011), the financial intermediary in our model is not an agent in the classical sense. Its only purpose is to transform bonds purchased by the household into loans for the traders. However, it does not make any decisions and hence does not behave according to any optimality conditions. We simply introduce the financial intermediary in order to explicitly model investment wedges between borrowers and lenders. However, we do not take a stand on the microfoundations of these wedges. Instead, we focus on quantifying the importance of our additional frictions for explaining the large tax multipliers of durables and capital investment.

Equilibrium

The competitive equilibrium in this model is given by a sequence of prices $\{w_t, r_t, q_{k,t}, q_{d,t}, p_{k,t}, p_{d,t}\}_{t=0}^{\infty}$, policies $\{\tau_{k,t}, \tau_{n,t}\}_{t=0}^{\infty}$, frictions $\{f_{k,t}, f_{d,t}\}_{t=0}^{\infty}$, and allocations $\{y_t, c_{y,t}, d_t, h_t, k_t, B_t, I_t, V_t, u_t, T_t, F_t\}_{t=0}^{\infty}$ that solve the optimization problems of all agents and satisfy equations (2.2)-(2.15). All markets clear. Specifically, bond market clearing requires:

$$L_t = L_{k,t} + L_{d,t} = B_t \tag{2.16}$$

and good market clearing requires:[15]

$$y_t = c_{y,t} + I_t + S_k\left(\frac{I_t}{I_{t-1}}\right) I_t + V_t + S_d\left(\frac{V_t}{V_{t-1}}\right) V_t + G \tag{2.17}$$

[15]Note that the friction loss F does not enter the good market clearing condition because it is given to the household as a lump-sum transfer and therefore, it is already included in consumption.

In a next step, we use our model in order to quantify the importance of our additional investment wedges, f_k and f_d, for explaining the large empirical tax multipliers of durables and capital investment. We do so by estimating the key parameters of the model by indirect inference. We then decompose the total response in order to understand the contribution of each of our four wedges. However, before proceeding to the estimation of our model, we need to define the stochastic processes that determine $\tau_{k,t}$, $\tau_{n,t}$, $f_{k,t}$, and $f_{d,t}$.

2.3.3 Definition of Stochastic Processes

The functional forms that we assume for utilization and investment adjustment costs are defined in Section 2.A.3 in the Appendix. The description of the stochastic processes for tax rates and for our additional investment wedges are provided in this subsection.

Tax Processes

Following McGrattan (1994) and Mertens and Ravn (2011), we assume that the tax rates follow an AR(2) process:

$$\tau_{k,t} = (1 - \rho_{k,1} - \rho_{k,2})\tau_k + \rho_{k,1}\tau_{k,t-1} + \rho_{k,2}\tau_{k,t-2} + \varepsilon_t^k \tag{2.18}$$

$$\tau_{n,t} = (1 - \rho_{n,1} - \rho_{n,2})\tau_n + \rho_{n,1}\tau_{n,t-1} + \rho_{n,2}\tau_{n,t-2} + \varepsilon_t^n \tag{2.19}$$

where τ_k and τ_n without time subscripts denote steady state tax rates.

Friction Processes

We assume that the capital and durables frictions follow an AR(2) process:[16]

$$f_{k,t} = (1 - \rho_{fk,1} - \rho_{fk,2})f_k + \rho_{fk,1}f_{k,t-1} + \rho_{fk,2}f_{k,t-2} + \varepsilon_{fk,t} \tag{2.20}$$

$$f_{d,t} = (1 - \rho_{fd,1} - \rho_{fd,2})f_d + \rho_{fd,1}f_{d,t-1} + \rho_{fd,2}f_{d,t-2} + \varepsilon_{fd,t} \tag{2.21}$$

where f_k and f_d without time subscripts denote steady state capital and durables frictions respectively. In our analysis, we distinguish between three different cases for $f_{k,t}$ and $f_{d,t}$. In our first specification, $f_{k,t}$ and $f_{d,t}$ are set to zero in all time periods. This corresponds to our baseline model, in which we only consider tax wedges. In our second specification, $f_{k,t} = f_k$ and $f_{d,t} = f_d$ are calibrated in steady state and are held constant over time. In a third specification, we furthermore allow $f_{k,t}$ and $f_{d,t}$ to react dynamically to tax

[16] Our assumption is based on the fact that the literature usually assumes an AR(2) process for tax wedges (see e.g. McGrattan 1994 and Mertens and Ravn 2011). Thus, we use the same stochastic process for our additional investment wedges.

changes. In that case, $\varepsilon_{fk,t}$ and $\varepsilon_{fd,t}$ depend on the deviation of tax revenues over final output, denoted by $\frac{TR}{y}$, from their steady state value, i.e. $\frac{TR_0}{y_0} - \frac{\overline{TR}}{\overline{y}}$. Specifically, the error terms are assumed to react on impact (i.e. in period $t = 0$) to a tax shock in the following way: $\varepsilon_{fk,0} = \xi_k \left(\frac{TR_0}{y_0} - \frac{\overline{TR}}{\overline{y}}\right)$ and $\varepsilon_{fd,0} = \xi_d \left(\frac{TR_0}{y_0} - \frac{\overline{TR}}{\overline{y}}\right)$. Thus, ξ_k and ξ_d determine the transmission from tax changes to our additional frictions. In our experiment, we set $\frac{TR_0}{y_0} - \frac{\overline{TR}}{\overline{y}} = 0.01$ and therefore, ξ_k and ξ_d can be directly interpreted as the percentage point increase in the interest rate wedges for capital and durable good traders.

Given the parametrization described above, the structural parameters of our model can be summarized in the vector Θ:

$$\Theta = [\alpha, \beta, \gamma, \delta_k, \delta_d, \nu, \phi, b, g, \tau_k, \tau_n, f_k, f_d, \sigma, \Psi, \pi, a, S_k'', ...$$
$$...S_d'', \rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}, \rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d]$$

We are now ready to proceed to the estimation of our model. In doing so, we will calibrate some basic parameters and estimate the remaining elements in Θ. The estimation procedure is described in the following section.

2.4 Estimation Strategy

In this section, we estimate the structural parameters of our model by matching our empirical and theoretical impulse responses.

2.4.1 Calibration

We divide the parameter vector Θ into two parts: $\Theta = [\Theta_1, \Theta_2]'$, where Θ_1 are the parameters that we calibrate based on empirical findings from the literature. Θ_2, on the other hand, are the parameters that we estimate by indirect inference. The two vectors contain the following parameters:

$$\Theta_1 = [\alpha, \beta, \gamma, \delta_k, \delta_d, \nu, \phi, b, g, \tau_k, \tau_n, f_k, f_d]$$
$$\Theta_2 = [\sigma, \Psi, \pi, a, S_k'', S_d'', \rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}, \rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d]$$

The values and sources used in the calibration of Θ_1 are summarized in Table 2.1. The elements of Θ_2, on the other hand, differ across specifications and are therefore listed separately for every version of the model in Section 2.5.

The capital share α in the Cobb-Douglas production function is assumed to be 36 percent and the discount factor β is set to an annual rate of 3 percent. Following Mertens

Table 2.1: Calibrated parameters

Param.	Explanation	Value	Target / Source
α	Capital share	0.36	Mertens and Ravn (2011)
β	Discount factor	0.9926	Annual rate of 3%
γ	Weight of hours	varies	Match 25% in steady state (Mertens and Ravn 2011)
δ_k	Capital depreciation	0.025	Mertens and Ravn (2011)
δ_d	Durable depreciation	0.025	Mertens and Ravn (2011)
ν	Final good production function	varies	Match $\bar{y} = 1$ in steady state
ϕ	Parameter in composite consumption	varies	Match 11.9% consumption share of durables in steady state (Mertens and Ravn 2011)
b	Capital utilization parameter	varies	Match $\bar{u} = 1$ in steady state
g	Government consumption	0.201	Mertens and Ravn (2011)
τ_k	Steady state capital income tax rate	0.42	Mertens and Ravn (2011)
τ_n	Steady state labor income tax rate	0.26	Mertens and Ravn (2011)
f_k	Steady state capital friction	0.016	Historical average of GZ spread by Gilchrist and Zakrajsek (2012)
f_d	Steady state durables friction	0.06	Historical average of car and personal loan spreads (FRED)

and Ravn (2011), the depreciation parameters for capital and durable goods, δ_k and δ_d, are equal to 2.5 percent.

The steady state share of government consumption in total output amounts to 20.1 percent and capital and labor income tax rates, τ_k and τ_n, are set to 42 and 26 percent respectively. These values correspond to the estimates reported by Mendoza, Razin, and Tesar (1994) and are similar to the ones found by Trabandt and Uhlig (2011).[17]

γ denotes the weight of labor in the utility function and is defined such that hours worked in steady state are equal to 25 percent of total available time. ϕ is set such that the steady state share of durable goods in total consumption is equal to 11.9 percent. ν multiplies the production function of final goods and is calibrated such that $\bar{y} = 1$ in steady state. The capital utilization parameter b is set to match a utilization rate of one, i.e. $\bar{u} = 1$, in steady state. The latter four parameter values differ across specifications and are reported in Section 2.5 for each version of the model, together with the values of the parameters in vector Θ_2.

Last but not least, we need to calibrate the steady state values of our frictions, f_k and f_d. As explained in the previous section, these wedges result in a spread between borrowing and lending rates in our model. Thus, we determine their values using the

[17] Trabandt and Uhlig (2011) find average effective labor and capital income tax rates for the US of 28 and 36 percent respectively. They apply the same methodology as Mendoza, Razin, and Tesar (1994), extending the time period used in their calculations. Additionally, Trabandt and Uhlig (2011) report an average share of tax revenues in total GDP of 18 percent.

historical average of credit spreads from the data as empirical counterparts.[18] For the capital friction, f_k, we compute the average of the GZ spread developed by Gilchrist and Zakrajsek (2012) for the entire time period available (i.e. from 1973M1-2010M9). The GZ spread is constructed based on micro-level data for securities by non-financial firms in the US. It therefore has a high information content and is not subject to the duration mismatch present in classical credit spreads. Accordingly, the capital friction, f_k, is set to 1.6 percentage points. For the durables friction, f_d, we rely on credit spreads for car and personal loans. Data are obtained from the FRED database.[19] We compute the average of the spread between personal loans (2 years) and Treasuries (2 years) for 1976Q1-2014Q4 and the average of the spread between car loans (4 years) and Treasuries (5 years) for 1972Q2-2014Q3. Taking into account the duration mismatch on car loan spreads, this yields an overall value of 6 percentage points for the durables friction in steady state.

Parameter Constraints

The parameters in Θ_2 are estimated subject to several constraints implied by theory. Specifically, values for the habit parameter range from zero to one, i.e. $0 \leq \pi < 1$. Furthermore, we restrict the parameters that determine adjustment costs and capital utilization to be greater or equal to zero: $S_k'' \geq 0$, $S_d'' \geq 0$, and $a \geq 0$.

Constraints on preference parameters are less straightforward. In particular, as our utility function features habit formation, we cannot interpret $\frac{1}{\sigma}$ as the intertemporal elasticity of substitution. Nevertheless, we can still interpret σ as the coefficient of relative risk aversion.[20] A risk aversion of zero implies risk neutrality and is not consistent with empirical findings. Following the literature (see e.g. Meier and Müller 2006), we restrict $\sigma > 1$. We furthermore limit $\psi \geq 0.5$, which implies a Frisch elasticity of less than 2.

For the autoregressive coefficients of the tax and friction processes, we require that the AR(2) is stable. This implies that both roots need to be smaller than 1. Specifically, we set an upper bound of 0.999 in order to make sure that the processes do not become unstable for small deviations. Furthermore, we require the roots to be non-complex. We do so by forcing $\rho_1^2 + 4\rho_2 \geq 0.01$.[21]

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[18] Note that Bernanke, Gertler, and Gilchrist (1999) also use historical averages in order to calibrate their friction in steady state.

[19] `http://research.stlouisfed.org/fred2/`, retrieved on March 16, 2015.

[20] The coefficient of relative risk aversion is defined as $\frac{-c_t u''(c_t)}{u'(c_t)}$ and does not have any intertemporal components. The intertemporal elasticity of substitution, on the other hand, is defined as $-\frac{\partial \ln[c_{t+1}/c_t]}{\partial \ln[u'(c_{t+1})/u'(c_t)]}$, which will be influenced by the habits property of our utility function.

[21] The roots are complex if this expression is smaller than zero. However, we need to make sure that we can still numerically differentiate our function with respect to the AR(2) parameters and this requires that they are not too close to being complex.

Initial Shocks

In order to ensure the comparability of our impulse responses, the initial tax shocks in the model, denoted by ε_0^k and ε_0^n, should correspond as closely as possible to the tax change considered in the empirical VAR. For this reason, we calibrate ε_0^k and ε_0^n such that the resulting change in tax revenues over final output corresponds to one percentage point, i.e. $\frac{TR_0}{y_0} = \frac{\bar{TR}}{\bar{Y}} + 0.01$, where the 'bar' on top of the variable denotes its steady state value.

In doing so, we have to make an assumption about the relative importance of capital and labor income taxes respectively. The reason is that the tax rates in our model are a theoretical construct and do not have a direct empirical counterpart.

In our benchmark case, we follow Mertens and Ravn (2011) and assume that both capital and labor income taxes are equally affected by the change in tax revenues, i.e. $\varepsilon_0^k = \varepsilon_0^n$. Section 2.A.4 in the Appendix describes the calibration of ε_0^k and ε_0^n under this assumption. We additionally consider the two extreme cases in which the entire change in tax revenues is solely driven by either capital or labor income taxes. In all three cases, the tax change may also affect the innovations of our capital and durables frictions, $f_{k,0}$ and $f_{d,0}$. The corresponding effect on impact is derived in Section 2.A.4 in the Appendix.

2.4.2 Estimation

Having calibrated and constrained our parameters, we are now ready to proceed to the actual estimation of Θ_2. We do so by using an impulse response matching strategy, which chooses the parameters such that the weighted distance between the empirical and model impulse responses is minimized. This approach is widely used in the literature, see e.g. Rotemberg and Woodford (1997), Edge (2000), Christiano, Eichenbaum, and Evans (2005), Meier and Müller (2006), and Mertens and Ravn (2011).

Denote the impulse responses of the model for a given set of parameters by $\Lambda^m(\Theta_2|\Theta_1)$ and the corresponding empirical impulse responses by $\hat{\Lambda}^e$. We want to choose our parameters in Θ_2 such that the model approximates the empirical impulse responses as closely as possible. According to Newey and McFadden (1994), the optimal $\hat{\Theta}_2$ solves the following minimization problem:

$$\begin{aligned} &\hat{\Theta}_2 = \arg\min_{\Theta_2} \mathcal{D} \\ &\textit{where} \quad \mathcal{D} = \left(\Lambda^m(\Theta_2|\Theta_1) - \hat{\Lambda}^e\right)' W \left(\Lambda^m(\Theta_2|\Theta_1) - \hat{\Lambda}^e\right) \end{aligned} \tag{2.22}$$

$\mathcal{D}$ is a measure for the weighted distance between the theoretical and empirical impulse responses and W is the weighting matrix. Efficient estimates require the use of the inverse of the covariance matrix of $\hat{\Lambda}^e$ for weighting. However, it has been shown in the literature[22] that, as the number of moment conditions gets large, the sample covariance matrix is not a good estimator of the true covariances. This problem is reinforced by the fact that we have to take the inverse of this matrix in order to calculate W. Therefore, it is common to use the diagonal elements of this matrix only. We follow the literature and define $W = \left[\hat{\Sigma}_d^e\right]^{-1}$, where $\hat{\Sigma}^e$ is the bootstrap estimate of the covariance matrix from the empirical VAR and $\hat{\Sigma}_d^e$ is a matrix containing its diagonal elements only. The variables for which we match the impulse responses are final output, investment, non-durables consumption, durables consumption, and hours worked. We minimize Equation (2.22) using numerical methods.

Standard errors are calculated following Newey and McFadden (1994).[23] The asymptotic variance of $\hat{\Theta}_2$ is given by:

$$\hat{\Sigma}^m = \widehat{Avar}(\hat{\Theta}_2) = \left[H' \left[\hat{\Sigma}_d^e\right]^{-1} H\right]^{-1} \tag{2.23}$$

where $H = \frac{\partial \Lambda^m(\Theta_2|\Theta_1)}{\partial \Theta_2}$ is the Jacobian of the model impulse responses.[24]

From the asymptotic variance, we can compute asymptotic standard errors:

$$\widehat{SE}(\hat{\Theta}_2) = \sqrt{\frac{\hat{\Sigma}^m}{T}} \tag{2.24}$$

where T is the sample size.[25]

There are two different ways to generate the model impulse responses $\Lambda^m(\Theta_2|\Theta_1)$. The first method obtains the deterministic responses directly from the solution of the model. The second approach, on the other hand, simulates data from the model and uses them in a VAR in order to compute the impulse responses. Mertens and Ravn (2011) show that both methods yield almost identical results. They only differ for very long forecast horizons. As the focus of our paper lies on the short run, we therefore choose the first approach, which has e.g. also been used by Meier and Müller (2006).

[22]See for example Bai and Shi (2011) and Hayakawa (2014).

[23]Theorem 4.1 in Newey and McFadden (1994) applies to extremum estimators and thus also to minimum distance estimators, as is stated on page 2155: "For minimum distance estimators, the choice between different consistent variance estimators can be based on considerations such as those discussed for extremum estimators, when the model is correctly specified."

[24]We use numerical differentiation in order to obtain H. The centered finite difference approximation of f at x is given by $f'(x) \approx \frac{f(x+h)-f(x-h)}{2h}$ for a very small h (see Miranda and Fackler 2002, page 98). The rule of thumb for the choice of the optimal h for two-sided approximations is given by $h = \max(|x|, 1) \cdot \varepsilon^{1/3}$ where ε is defined as the machine epsilon or machine precision (page 103).

[25]T is equal to the number of time periods in our case.

In the following section, we use numerical methods in order to conduct our impulse response matching. Specifically, we apply the methodology described above in order to estimate the parameters in $\Theta_2 = [\sigma, \Psi, \pi, a, S''_k, S''_d, \rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}, \rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d]$.

2.5 Results

The goal of this section is to quantify the size of our additional investment frictions that are needed in order to match the large empirical tax multipliers for durables purchases and investment. For this purpose, we conduct an experiment in which we estimate three different specifications of our model. In a first step, we establish a benchmark and present the results for our model with capital and labor tax wedges only. In a second step, we introduce our additional investment frictions and hold them constant over time. In the third specification, we allow our capital and durables frictions to react dynamically to tax changes.

Review of Stochastic Processes

Before proceeding to the experiment, it is useful to recall the definition of the stochastic processes of our four wedges.

AR(2) process for tax rates:

$$\begin{aligned}
\tau_{k,t} &= (1-\rho_{k,1}-\rho_{k,2})\tau_k + \rho_{k,1}\tau_{k,t-1} + \rho_{k,2}\tau_{k,t-2} + \varepsilon_t^k \\
\tau_{n,t} &= (1-\rho_{n,1}-\rho_{n,2})\tau_n + \rho_{n,1}\tau_{n,t-1} + \rho_{n,2}\tau_{n,t-2} + \varepsilon_t^n
\end{aligned}$$

where τ_k and τ_n without time subscripts denote steady state capital and labor income tax rates respectively.

AR(2) processes for investment frictions:

$$\begin{aligned}
f_{k,t} &= (1-\rho_{fk,1}-\rho_{fk,2})f_k + \rho_{fk,1}f_{k,t-1} + \rho_{fk,2}f_{k,t-2} + \varepsilon_{fk,t} \\
f_{d,t} &= (1-\rho_{fd,1}-\rho_{fd,2})f_d + \rho_{fd,1}f_{d,t-1} + \rho_{fd,2}f_{d,t-2} + \varepsilon_{fd,t}
\end{aligned}$$

where f_k and f_d without time subscripts denote steady state capital and durables frictions respectively.

Furthermore, we define:

$$\varepsilon_{fk,0} = \xi_k \underbrace{\left(\frac{TR_0}{y_0} - \frac{\overline{TR}}{\overline{y}}\right)}_{=0.01}$$
$$\varepsilon_{fd,0} = \xi_d \underbrace{\left(\frac{TR_0}{y_0} - \frac{\overline{TR}}{\overline{y}}\right)}_{=0.01}$$

Hence, ξ_k and ξ_d determine the transmission from tax changes to our investment frictions and can be directly interpreted as the percentage point increase in the interest rate wedges for capital and durable good traders.

The dynamics of our four wedges depend on the following fourteen parameters: $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}, \tau_k, \tau_n, \rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d, f_k, f_d$. The steady state tax rates are calibrated to $\tau_k = 0.42$ and $\tau_n = 0.26$, as explained in Section 2.4.1. The values for the remaining twelve parameters, on the other hand, are allowed to differ across specifications.

Experiment Design and Preview of Results

In order to quantify the importance of our additional investment frictions, $f_{k,t}$ and $f_{d,t}$, we conduct an experiment. Specifically, we estimate our model for three different specifications. We start from a benchmark model without $f_{k,t}$ and $f_{d,t}$ and then gradually increase the impact of our additional investment frictions.

In our first specification, we allow for capital and labor income taxes only. Specifically, we estimate the AR(2) processes of the two tax wedges such that the model impulse responses match their empirical counterparts as closely as possible. In terms of the parameters of our model, this means that $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}$ are estimated, whereas $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d$ and the steady state frictions, f_k and f_d, are set to zero. Our results show that the standard model with tax wedges cannot account for the large reaction of durables purchases and investment to a tax change in the data. This finding is robust even if we consider the two extreme cases in which the entire tax increase is driven by either the capital income tax or the labor income tax alone. We then show that incorporating additional investment frictions into our model can improve the fit in this dimension significantly.

In our second specification, in addition to our two tax wedges, we allow for capital and durables investment frictions that are constant over time. Specifically, we assume $f_{k,t} = f_k = 0.016 \; \forall t$ and $f_{d,t} = f_d = 0.06 \; \forall t$ and estimate $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}$.

The parameters that determine the investment friction dynamics, on the other hand, i.e. $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d$, are set to zero. We find that this improves the match of our model for durables and investment. However, the tax multipliers implied by the model are still not as high as their empirical counterparts.

Therefore, in our third specification, we allow the investment frictions to react dynamically to tax changes. Here, we calibrate $f_k = 0.016$ and $f_d = 0.06$ in steady state and estimate all the remaining parameters for our tax wedges, $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}$, and for our investment frictions, $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d$, such that the model and empirical impulse responses are as close to each other as possible. In this case, our model is able to match the data very well. In order to do so, it requires an initial increase of the capital and durables frictions of $\xi_k = 5.4$ and $\xi_d = 0.23$ percentage points respectively. These two coefficients are significantly different from each other.

We conclude that in order to match the large investment and durables multipliers in the data, we need a model that – on top of the standard labor and capital tax wedges – allows for two additional investment frictions. These frictions need to react dynamically to tax changes. Furthermore, their size and dynamics should be allowed to differ for capital and durable goods.

Our results are interesting because they provide guidance for the modeling of the transmission of tax changes. According to our findings, a good model should generate a positive comovement between investment wedges and tax shocks and should allow for different capital and durables investment wedges. For example, if we interpret our investment wedges as financial frictions, as in Hall (2011), then our findings also imply that financial frictions might play an important role in the transmission of tax changes. Given that there are many different, competing ways of modeling financial frictions, our results can be used to choose the most appropriate model.

In the remainder of this section, we present the results for our three specifications and discuss their implications.

2.5.1 Specification 1: Dynamic Tax Wedges and No Investment Frictions

In this subsection, we estimate the model with tax wedges only, abstracting from our additional investment frictions. Thus, we set $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d, f_k, f_d$ to zero. The parameters that determine the dynamics of our tax wedges, on the other hand, are estimated. We distinguish three different cases for the composition of tax rates.

In the first case, we assume that both labor and capital income taxes contribute to the tax increase in $t = 0$, i.e. $\varepsilon_0^k = \varepsilon_0^n$. Furthermore, we estimate all four AR(2) parameters

$\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}$ for the two tax rates. We will refer to this case as our benchmark in the remainder of the analysis.

In the second case, we consider an extreme example in which only capital income taxes increase. Thus, we set all parameters for the labor tax wedge, i.e. $\varepsilon_0^n, \rho_{n,1}, \rho_{n,2}$, to zero, except for its steady state value, which is still calibrated to $\tau_n = 0.26$. We then estimate the reaction of capital taxes only, i.e. $\rho_{k,1}, \rho_{k,2}$.

The third case presents results for the other extreme in which only labor income taxes react. Accordingly, we estimate $\rho_{n,1}, \rho_{n,2}$ and set $\varepsilon_0^k, \rho_{k,1}, \rho_{k,2}$ to zero. The steady state capital tax is again equal to its calibrated value, i.e. $\tau_k = 0.42$.

Last but not least, we compare the impulse responses generated by our benchmark model to the ones obtained by Mertens and Ravn (2011).

Case 1 (Benchmark): Capital and Labor Income Taxes Only

In a first step, we estimate our model with capital and labor income taxes, setting our additional investment frictions, $f_{k,t}$ and $f_{d,t}$, to zero. We impose that the initial tax innovation is identical for both tax rates, i.e. $\varepsilon_0^k = \varepsilon_0^n$. They are calibrated such that tax revenues over final output in the model increase by one percentage point – exactly as in the empirical estimation. The tax rate dynamics in the periods after the shock are determined by the parameters $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}$, which are estimated such that the distance between the model and empirical impulse responses is minimized. All the remaining parameters, i.e. $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d, f_k, f_d$, are set to zero.

The resulting parameter estimates and their standard errors are reported in Table 2.2. All coefficients are highly significant. First, we discuss the preference parameters. The curvature of consumption in the utility function, denoted by σ, is estimated to be equal to 4.07, which is similar to the value found by Mertens and Ravn (2011). While this seems to be rather high, it is hard to define a reasonable range for σ in our setting. The reason is that our utility function features habit formation. Therefore, we cannot interpret $\frac{1}{\sigma}$ as the intertemporal elasticity of substitution. The inverse of the curvature of hours, $\frac{1}{\Psi}$, on the other hand, can be interpreted as the Frisch elasticity of labor, which is estimated to be equal to 1.5. As documented in a meta analysis by Chetty et al. (2011), this value lies within the range of existing estimates for macro models. Our habit parameter estimate, π, amounts to 0.79. It is close to the value of 0.73 found by Boldrin, Christiano, and Fisher (2001) and reflects a strong motive for consumption smoothing.

The point estimates for the parameters that determine adjustment costs for capital and durables investment, denoted by S_k'' and S_d'', are given by 1.06 and 0.76 respectively. These values are relatively low, which means that it is not very costly to change investment. The high significance of both coefficients, however, indicates that they both play an important

Table 2.2: Coefficient estimates for Specification 1, Case 1

Parameter	**Explanation**	**Value**	**Standard Error**
σ	Consumption curvature	4.07***	(0.16)
Ψ	Hours curvature	0.67***	(0.17)
γ	Weight of hours	6265^c	
π	Habit parameter	0.79***	(0.01)
ϕ	Composite consumption	0.99^c	
ν	Final good production function	1.08^c	
a	Capital utilization parameter	0.04**	(0.02)
b	Capital utilization parameter	0.04^c	
S''_k	Capital adjustment costs	1.06***	(0.09)
S''_d	Durables adjustment costs	0.76***	(0.06)
$\rho_{k,1}$	AR(2) for capital taxes	1.70***	(0.06)
$\rho_{k,2}$	AR(2) for capital taxes	-0.72***	(0.06)
$\rho_{n,1}$	AR(2) for labor taxes	1.59***	(0.03)
$\rho_{n,2}$	AR(2) for labor taxes	-0.59***	(0.03)
$\rho_{fk,1}$	AR(2) for capital friction	-	
$\rho_{fk,2}$	AR(2) for capital friction	-	
$\rho_{fd,1}$	AR(2) for durables friction	-	
$\rho_{fd,2}$	AR(2) for durables friction	-	
ξ_k	Initial response of capital friction	-	
ξ_d	Initial response of durables friction	-	
f_k	Steady state capital friction	0^c	
f_d	Steady state durables friction	0^c	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. c marks parameters that are not estimated because they are calibrated in steady state. n marks parameters that hit a natural bound.

role. This is in line with the findings by Christiano, Eichenbaum, and Evans (2005), who demonstrate that adjustment costs and habit formation are crucial for their model dynamics. In our model, adjustment costs generate the hump shape in the responses of investment.

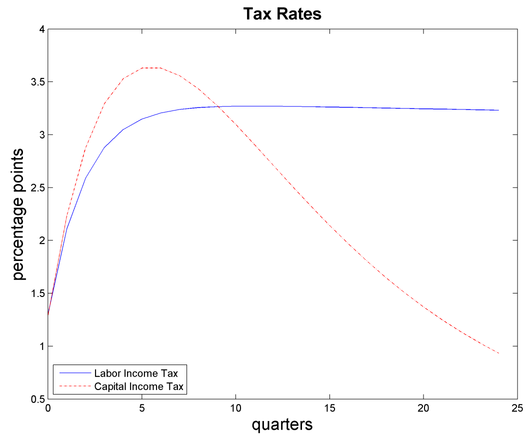
The capital utilization parameter a, on the other hand, is estimated to be equal to 0.04. This implies that it is very cheap to adjust utilization, which is important in our model because – as explained below – there is a trade-off between matching output and hours in our model. If utilization can be adjusted, then the model can generate a larger decrease in final output without having to rely solely on a reduction in hours worked.

The estimated parameters for the AR(2) process of the capital tax rates are $\rho_{k,1} = 1.70, \rho_{k,2} = -0.72$, and for the labor tax rate $\rho_{n,1} = 1.59, \rho_{n,2} = -0.59$. The dynamics for the tax rates implied by these coefficients are displayed in Figure 2.4.

Both tax rates initially increase by $\varepsilon_0^k \cdot 100 = \varepsilon_0^n \cdot 100 = 1.3$ percentage points. Labor tax rates are highly persistent, while the decrease in capital tax rates is much faster.

Given the stochastic processes and the parameters described above, we are now in a position to compute the impulse responses of the model and to compare them to their

Figure 2.4: Taxes in Specification 1, Case 1



Notes: Estimated dynamics of capital and labor income tax rates in the model without investment frictions.

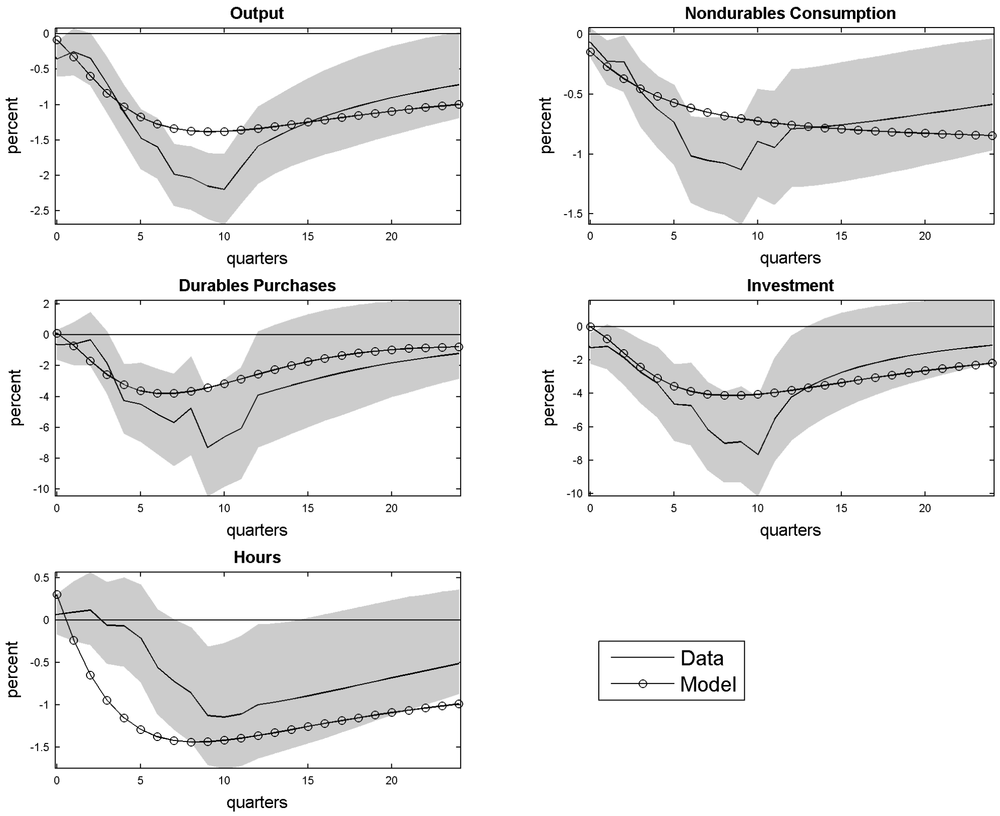
empirical counterparts. The resulting dynamics are shown in Figure 2.5. The lines with circles represent the responses from our model. The solid lines, together with the shaded areas around them, correspond to our empirical impulse responses and their 68 percent confidence bands. We display them for a horizon of 24 quarters after the tax change.

First, consider the impulse responses from our model. All our variables decrease after the tax shock. At the peak, output goes down by 1.4 percent, durables purchases by 3.8 percent, investment by 4.1 percent, and hours worked by 1.4 percent. Nondurables consumption declines steadily.

The model impulse responses seem to match the shape of their empirical counterparts quite well. However, the size of the tax multipliers generated by the model is too low for output, durables purchases, investment, and nondurables consumption. Hours worked, on the other hand, overshoot in the sense that the model response lies below the confidence bands from the empirical estimation for many quarters.

Apparently, there is a trade-off between output and hours in our model. We will later show that this mismatch can be (and has been) addressed by introducing an additional efficiency wedge. In contrast, the literature has not been able to explain the fact that the model underestimates the high empirical tax multipliers for durables purchases and investment (see e.g. Mertens and Ravn 2011 and Zubairy 2014). In the following, we show that this finding persists even if we depart from our assumption that both capital and labor taxes contribute equally to a tax change. Specifically, we conduct two exercises. In the first one, we generate the entire change in tax revenues by an increase in capital income taxes only. In the other extreme, we assume that the tax shock is entirely driven by labor income taxes.

Figure 2.5: Impulse responses for Specification 1, Case 1



Notes: Model impulse responses to a shock in capital and labor income taxes in the model without investment frictions. The solid line represents empirical impulse responses, with the shaded areas corresponding to 68 percent confidence intervals.

Case 2: Capital Income Taxes Only

One reason why our benchmark model underestimates the empirical response of durables purchases and investment might be that we assume an equal increase in the capital and labor income tax rate on impact. Chari, Kehoe, and McGrattan (2007) show that a capital tax gives rise to an investment wedge. Therefore, a higher contribution of the capital tax relative to the labor income tax can potentially increase the tax multipliers on investment and durables purchases. In that case, the problem might be solved by simply giving more weight to the capital income tax in the model. Accordingly, there would be no need for any additional investment wedges in our model.

In order to test this hypothesis, we conduct an exercise in which the entire increase in tax revenues is driven by the capital tax. Labor income taxes, on the other hand, stay constant at their steady state value, i.e. $\tau_n = 0.26$, at all points in time, with all the corresponding parameters, $\varepsilon_0^n, \rho_{n,1}, \rho_{n,2}$, set to zero. We then estimate the autoregressive parameters for the capital income tax rate, $\rho_{k,1}, \rho_{k,2}$, such that the weighted distance between the empirical and theoretical impulse responses is minimized. All the parameters that determine our additional investment frictions, i.e. $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d, f_k, f_d$, are again set to zero.

It is important to note that this is a purely theoretical exercise. In reality, labor income taxes do of course also play a role. However, the extreme case with capital taxes only allows us to determine an upper bound for the ability of our model to fit the large empirical durables and investment multipliers for different compositions of taxes.

Figure 2.A.1 in the Appendix shows the dynamics of the capital income tax. As it is responsible for the entire increase of one percentage point in tax revenues relative to output, the tax rate is much higher than in the case with both taxes. Specifically, the capital tax rate goes up by $\varepsilon_0^k \cdot 100 = 8.7$ percentage points on impact. The corresponding impulse responses of our model are presented in Figure 2.A.2 in the Appendix.

As expected, the investment wedge inherent in the capital income tax leads to larger tax multipliers for investment and durables purchases. However, they are still much lower than in the data. Our model generates a maximum decrease in durables purchases by 4.1 percent (vs. 7.3 percent in the data) and of 4.5 percent in investment (vs. 7.7 percent in the data). This confirms that investment wedges do indeed have the potential to increase tax multipliers of the latter two variables. However, the capital tax alone is not able to explain their large empirical responses.

The overall fit of the other variables is of course worse than in our benchmark specification with both capital and labor income taxes. Output only declines by 1.1 percent. Furthermore, there is almost no reaction of nondurables consumption in our model. The reason for this is the lack of a labor wedge in this one-sided specification, which is apparently important to ensure a good fit.

The focus of this exercise lies on the size of the durables and investment multipliers. We are not interested in the parameter estimates. However, for the sake of completeness, we report them in Table 2.A.1 in the Appendix. Many parameters take on extreme values. This indicates that the model finds it difficult to match the responses of all variables without a labor wedge and therefore needs to resort to unrealistic parameter values.

Hence, our original assumption that both the capital and labor income tax should contribute to the increase in tax revenues seems to be justified. There is of course no particular reason why both tax rates should change by exactly the same amount. However, our analysis is robust to different tax mixes. Even if we consider a maximum weight on the capital tax, our model still underestimates the tax multipliers on durables purchases and investment.

In a next step, we consider the other extreme case in which only labor income taxes change.

Case 3: Labor Income Taxes Only

In this exercise, we hold capital taxes constant at their steady state value, i.e. $\tau_k = 0.42$. The entire shock to tax revenues is driven by labor income taxes. Accordingly, we estimate $\rho_{n,1}, \rho_{n,2}$, and we set $\varepsilon_0^k, \rho_{k,1}, \rho_{k,2}$ and $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d, f_k, f_d$ to zero.

In the notation of Chari, Kehoe, and McGrattan (2007), the impact of the labor wedge in this specification is at its maximum. However, there is no wedge that distorts intertemporal equilibrium conditions, such as e.g. an investment wedge induced by capital taxes. Therefore, the estimated tax multipliers for investment and durables purchases are smallest in this case. Specifically, both of them are equal to 3.5 percent.

The corresponding tax dynamics and impulse responses of the model are shown in Figures 2.A.3 and 2.A.4 in the Appendix. Table 2.A.2 in the Appendix reports the estimated parameter values. However, we are not particularly interested in the details of this case. The only purpose of this exercise is to provide us with an estimate for the lower bound of the tax multipliers on durables purchases and investment that our model can generate.

Summary

In our model, we need to make an assumption about the relative contributions of capital and labor income taxes to the initial shock to tax revenues. Following Mertens and Ravn (2011), our benchmark specification in Case 1 assumes that both tax rates increase by the same amount on impact. This gives rise to tax multipliers of 3.8 percent for durables purchases and of 4.1 percent for investment. These values are much lower than their empirical counterparts, which are estimated to be equal to 7.3 percent and 7.7 percent respectively.

We show that this finding is robust to variations in the composition of the tax mix. We do so by considering two extreme cases. In Case 2, only capital taxes are shocked, which gives the maximum weight to the corresponding investment wedge. In Case 3, on the other hand, the entire tax increase is driven by labor income taxes. The investment wedge is held constant and the labor wedge works at its full potential.

Based on our results for Cases 2 and 3, our model can generate tax multipliers for durables purchases between 3.5 and 4.1 and for investment between 3.5 and 4.5. Thus, the finding that conventional models underestimate the responses of the latter two variables is independent of the tax mix. Therefore, in the remainder of our analysis, we focus on the case with identical innovations for both tax rates, which imposes $\varepsilon_0^k = \varepsilon_0^n$.

Comparison to Mertens and Ravn (2011)

In the following, we contrast our benchmark results to the ones found by Mertens and Ravn (2011). Their paper is a suitable reference point because we work with the same empirical impulse responses, which ensures comparability. Furthermore, our models share most of the features that have been shown to be important for the transmission of tax changes, such as investment adjustment costs, habit formation, and varying capital utilization. However, there are also some aspects in which the models differ from each other. The main difference concerns the way in which capital taxes are modeled.[26] Mertens and Ravn (2011) tax the return on utilized capital. In the notation of Chari, Kehoe, and McGrattan (2007), the tax on capital gives rise to an investment wedge that distorts intertemporal decisions and the tax on utilization affects intratemporal equilibrium conditions in the form of an efficiency wedge. In our model, on the other hand, capital taxes are levied on the returns to bonds, which are independent of contemporaneous decisions. Therefore, our capital tax acts as an investment wedge only. This allows us to clearly separate different wedges, which is key for our experiment. However, it comes at the cost of a worse fit of the model in the intratemporal dimension due to the lack of an additional efficiency wedge.

The goal of this paper is to quantify the additional investment wedges needed in our model so that it is able to match the large empirical responses of durables purchases and investment. The match for these two variables is almost identical in our baseline model and in the model by Mertens and Ravn (2011). This confirms that the difference in wedges induced by the capital tax does not affect our main variables of interest. However, it does of course have an effect on the match of our other variables. This can most clearly be seen from the impulse responses of output and hours. In our model, there seems to be a trade-off between these two variables, which can be mitigated by an additional efficiency wedge, as implemented by Mertens and Ravn (2011). Therefore, their model is better able to match these two variables than our model. However, for the purpose of our experiment, this is not a concern because it obviously does not have an impact on the fit of investment in capital and durable goods. Therefore, we leave it to further research to quantify the size of the efficiency wedge. Instead, in this paper, we entirely focus on investment wedges.

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[26] Mertens and Ravn (2011) furthermore consider depreciation allowances and labor-augmenting technology, which grows at a constant rate. We abstract from these features because they are not important for our analysis. In particular, if we fix the growth rate of technology at one for each point in time in the model by Mertens and Ravn (2011), their impulse responses do not change. Depreciation allowances, on the other hand, seem to reduce the response of capital investment in the model by Mertens and Ravn (2011) even more, which increases the discrepancy between the empirical and theoretical impulse responses. In the presence of depreciation allowances, our model would therefore require even higher investment wedges for capital, $f_{k,t}$. Thus, our results should be interpreted as a lower bound for the importance of the additional investment wedges.

In the following, we therefore introduce additional investment frictions for capital and durable goods, denoted by $f_{k,t}$ and $f_{d,t}$. In Specification 2, those frictions are held constant after a tax shock. In Specification 3, they are allowed to comove with tax changes.

2.5.2 Specification 2: Dynamic Tax Wedges and Constant Investment Frictions

The estimation of Specification 1 demonstrates that our model with tax wedges is not able to explain the large empirical tax multipliers of durables purchases and investment. In the following two subsections, we show that this problem can be solved by introducing additional investment wedges. In particular, we incorporate two separate investment frictions for capital and durable goods into our model. In Specification 2, we first analyze by how much our results improve if we simply consider static frictions. In Specification 3, we then allow the frictions to react dynamically to tax changes.

In the present specification, our frictions are assumed to be constant. Therefore, we calibrate them to $f_{k,t} = f_k = 0.016 \ \forall t$ and $f_{d,t} = f_d = 0.06 \ \forall t$ and set all the parameters that determine the friction dynamics, i.e. $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d$, to zero. Both capital and labor tax rates are again assumed to increase by the same amount on impact, i.e. $\varepsilon_0^k = \varepsilon_0^n$. We then estimate the tax rate dynamics that are determined by the parameters $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}$.

Table 2.3 reports the resulting parameter values. All point estimates are very similar to the ones found in our benchmark case in Specification 1. Furthermore, they are again highly significant.

The tax dynamics are displayed in Figure 2.6. The initial increase in both tax rates is equal to $\varepsilon_0^k \cdot 100 = \varepsilon_0^n \cdot 100 = 1.4$ percentage points. The dynamic pattern follows closely the one from Specification 1. Labor income taxes exhibit a higher persistence than capital taxes.

The impulse responses following a tax shock are presented in Figure 2.7. The solid lines with the shaded area again display the empirical impulse responses. The dotted lines correspond to the results from Specification 2, and the lines with circles represent the findings from our benchmark estimation without additional investment frictions, i.e. Specification 1. The most striking difference concerns investment. Here, the tax multiplier at the peak increases from 4.1 percent in the benchmark to 5.4 percent in Specification 2. The match of durables purchases also improves a tiny bit on impact. For the remaining variables, the impulse responses of the two specifications are very close to each other.

In conclusion, we find that the introduction of two constant additional investment frictions for capital and durable goods brings our model closer to the data. This confirms that these elements play an important role. However, the model in Specification 2 is

Table 2.3: Coefficient estimates for Specification 2

Parameter	Explanation	Value	Standard Error
σ	Consumption curvature	4.16***	(0.19)
Ψ	Hours curvature	0.51***	(0.18)
γ	Weight of hours	4727^c	
π	Habit parameter	0.80***	(0.01)
ϕ	Composite consumption	0.99^c	
ν	Final good production function	1.22^c	
a	Capital utilization parameter	0.04*	(0.02)
b	Capital utilization parameter	0.05^c	
S_k''	Capital adjustment costs	0.92***	(0.06)
S_d''	Durables adjustment costs	1.12***	(0.09)
$\rho_{k,1}$	AR(2) for capital taxes	1.71***	(0.06)
$\rho_{k,2}$	AR(2) for capital taxes	-0.72***	(0.05)
$\rho_{n,1}$	AR(2) for labor taxes	1.57***	(0.04)
$\rho_{n,2}$	AR(2) for labor taxes	-0.57***	(0.04)
$\rho_{fk,1}$	AR(2) for capital friction	-	
$\rho_{fk,2}$	AR(2) for capital friction	-	
$\rho_{fd,1}$	AR(2) for durables friction	-	
$\rho_{fd,2}$	AR(2) for durables friction	-	
ξ_k	Initial response of capital friction	-	
ξ_d	Initial response of durables friction	-	
f_k	Steady state capital friction	0.016^c	
f_d	Steady state durables friction	0.06^c	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. c marks parameters that are not estimated because they are calibrated in steady state. n marks parameters that hit a natural bound.

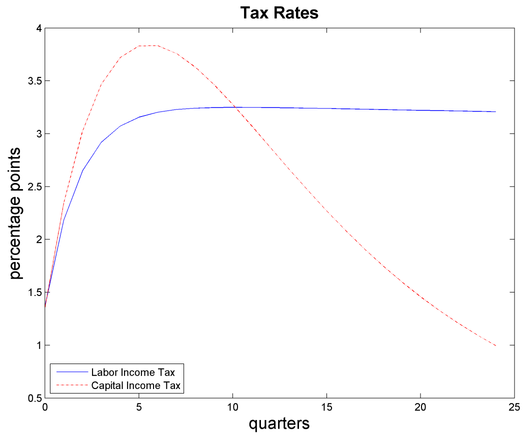
still not able to match the large empirical tax multipliers for durables purchases and investment. Therefore, in a next step, we allow the two additional investment frictions to react dynamically to a tax shock.

2.5.3 Specification 3: Dynamic Tax Wedges and Dynamic Investment Frictions

Specification 1 shows that a model with tax wedges alone cannot account for the large empirical tax multipliers of durables purchases and investment. In Specification 2, we demonstrate that the introduction of two constant additional investment frictions can improve the fit of our model. However, there is still a substantial gap between theoretical and empirical impulse responses. Therefore, in the present specification, we now allow the investment frictions to react dynamically to a tax change.

The transmission of tax shocks to the frictions, $f_{k,t}$ and $f_{d,t}$, is determined by the parameters ξ_k and ξ_d. Specifically, an increase in tax revenues relative to final output by one percentage point translates into innovations for the capital and durables friction of

Figure 2.6: Taxes in Specification 2



Notes: Estimated dynamics of capital and labor income tax rates in the model with constant investment frictions.

$\varepsilon_{fk,0} = \xi_k \cdot 0.01$ and $\varepsilon_{fd,0} = \xi_d \cdot 0.01$ respectively. Hence, ξ_k and ξ_d are the key parameters that we estimate in this specification.

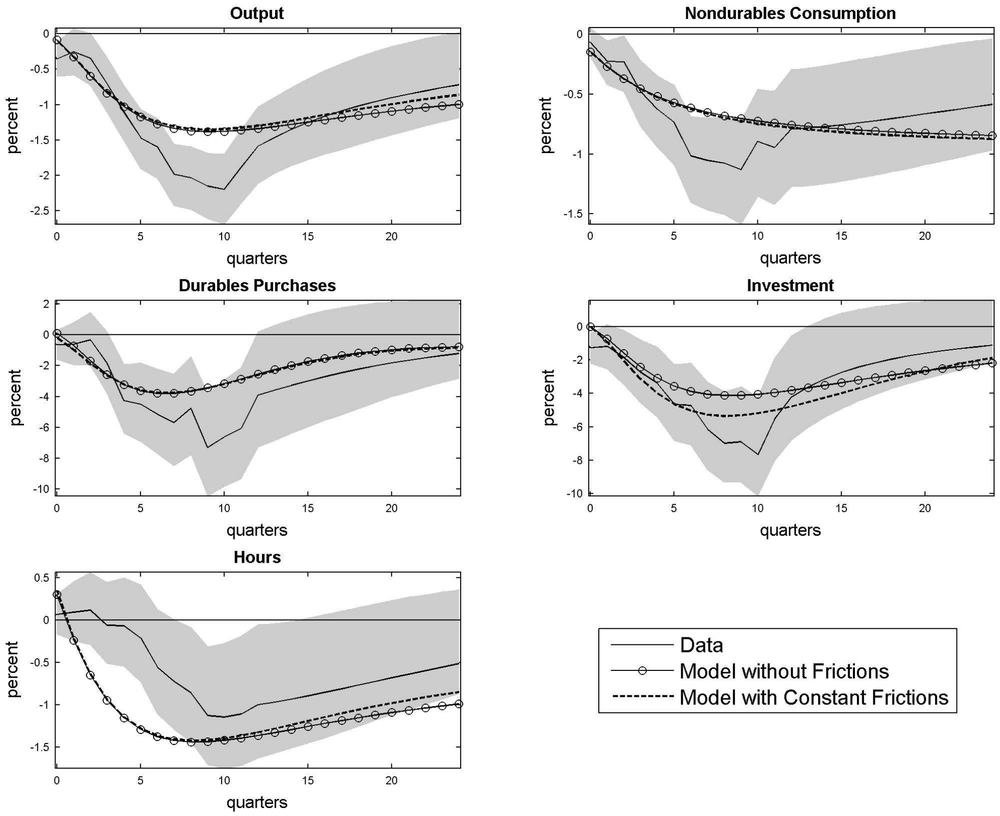
After the initial shock, frictions $f_{k,t}$ and $f_{d,t}$ are assumed to follow an AR(2) process with parameters $\rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}$, which are estimated such that the model impulse responses fit their empirical counterparts as closely as possible. The steady state values of the frictions are calibrated to $f_k = 0.016$ and $f_d = 0.06$. In addition to the dynamics of our investment frictions, we furthermore estimate the autoregressive parameters for our tax wedges, given by $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}$.

The coefficient estimates for Specification 3 are reported in Table 2.4. In the following, we discuss the resulting parameter values and compare them to the benchmark, given by Case 1 in Specification 1.

Our preference parameters become more extreme compared to the benchmark specification. Specifically, we find a Frisch elasticity of $\frac{1}{\Psi} = 2$. This value is at the upper bound of empirical estimates for macro models (see e.g. Chetty et al. 2011). Furthermore, the consumption curvature parameter in the utility function, σ, is estimated to be equal to 7.33. This value increases compared to the benchmark specification, in which it is already rather high. Reassuringly, in Subsection 2.A.6 in the Appendix, we show that our findings are robust if we place an upper limit on σ in the estimation.

Our habit parameter, π, on the other hand, is now estimated to be 0.75, which brings it even closer to the coefficient of 0.73 documented by Boldrin, Christiano, and Fisher (2001). Moreover, we find that the parameter for capital utilization a, is identical to its counterpart from the benchmark. A value of 0.04 again indicates that it is easy to adjust utilization, which reflects the fact that the trade-off between output and hours is still

Figure 2.7: Impulse responses for Specification 2



Notes: Model impulse responses to a shock in capital and labor income taxes in the model with and without constant investment frictions. The solid line represents empirical impulse responses, with the shaded areas corresponding to 68 percent confidence intervals.

present in our model.

The point estimates for the adjustment cost parameters of capital and durables investment are equal to $S_k'' = 0$ and $S_d'' = 3.6$ respectively. Thus, they differ substantially from their benchmark values. Specifically, capital adjustment costs are no longer significant. This contradicts the empirical findings by Cooper and Haltiwanger (2006), who find evidence for the presence of capital adjustment costs on the plant level. In the Appendix in Subsection 2.A.6, we therefore provide a robustness check, in which we show that our results are robust if we impose a lower bound on the capital adjustment cost parameter. However, the value of ξ_k, the parameter that determines the initial response of the capital friction, $f_{k,t}$, to a tax shock, becomes a bit lower than in the present specification. This indicates that the hump shape in investment can be generated by both adjustment costs or the capital friction.

The estimated AR(2) processes for the tax rates are very similar to the benchmark.

Table 2.4: Coefficient estimates for Specification 3

Parameter	**Explanation**	**Value**	**Standard Error**
σ	Consumption curvature	7.33***	(0.16)
Ψ	Hours curvature	0.50***	(0.10)
γ	Weight of hours	801155^c	
π	Habit parameter	0.75***	(0.01)
ϕ	Composite consumption	0.99^c	
ν	Final good production function	1.22^c	
a	Capital utilization parameter	0.04*	(0.03)
b	Capital utilization parameter	0.05^c	
S_k''	Capital adjustment costs	0^n	(-)
S_d''	Durables adjustment costs	3.60***	(0.19)
$\rho_{k,1}$	AR(2) for capital taxes	1.70***	(0.08)
$\rho_{k,2}$	AR(2) for capital taxes	-0.72***	(0.07)
$\rho_{n,1}$	AR(2) for labor taxes	1.66***	(0.02)
$\rho_{n,2}$	AR(2) for labor taxes	-0.66***	(0.02)
$\rho_{fk,1}$	AR(2) for capital friction	0.63***	(0.01)
$\rho_{fk,2}$	AR(2) for capital friction	-0.10***	(0.01)
$\rho_{fd,1}$	AR(2) for durables friction	0.94^n	(-)
$\rho_{fd,2}$	AR(2) for durables friction	0.00^n	(-)
ξ_k	Initial response of capital friction	5.38***	(0.15)
ξ_d	Initial response of durables friction	0.23***	(0.01)
f_k	Steady state capital friction	0.016^c	
f_d	Steady state durables friction	0.06^c	

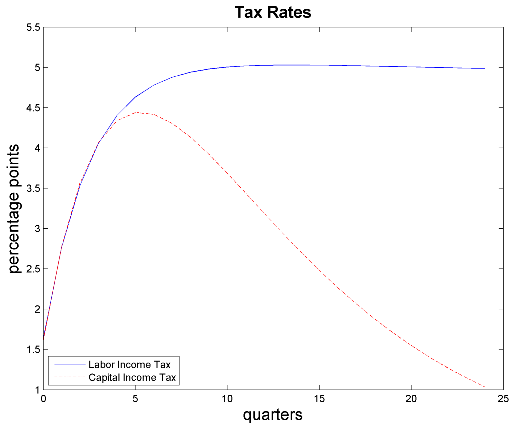
Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. c marks parameters that are not estimated because they are calibrated in steady state. n marks parameters that hit a natural bound.

Both tax rates initially increase by $\varepsilon_0^k \cdot 100 = \varepsilon_0^n \cdot 100 = 1.6$ percentage points. As illustrated in Figure 2.8, the labor income tax is again more persistent than the capital tax.

In a next step, we finally discuss the estimates for our additional investment wedges. Most importantly, we find a highly significant transmission of tax changes to the frictions, determined by ξ_k and ξ_d. After a tax shock that increases tax revenues relative to final output by one percentage point, the capital friction, $f_{k,t}$, increases by 5.38 percentage points and the durables friction, $f_{d,t}$, goes up by 0.23 percentage points. The estimated dynamics after the initial shock are presented in Figure 2.9. Whereas the capital friction goes back to its steady state after a few quarters, the durables friction rather behaves like an AR(1) process and declines more slowly. This is also reflected in an estimate of zero for the second autoregressive parameter of the durables friction, $\rho_{fd,2}$, as reported in Table 2.4.

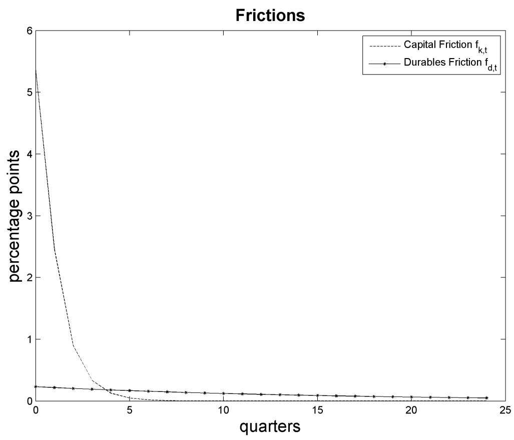
The impulse responses for all our variables are displayed in Figure 2.10. Our results from Specification 3 are represented by the dotted lines. For the sake of comparability, the lines with circles correspond to the responses from our benchmark specification, i.e.

Figure 2.8: Taxes in Specification 3



Notes: Estimated dynamics of capital and labor income tax rates in the model with dynamic investment frictions.

Figure 2.9: Friction dynamics in Specification 3



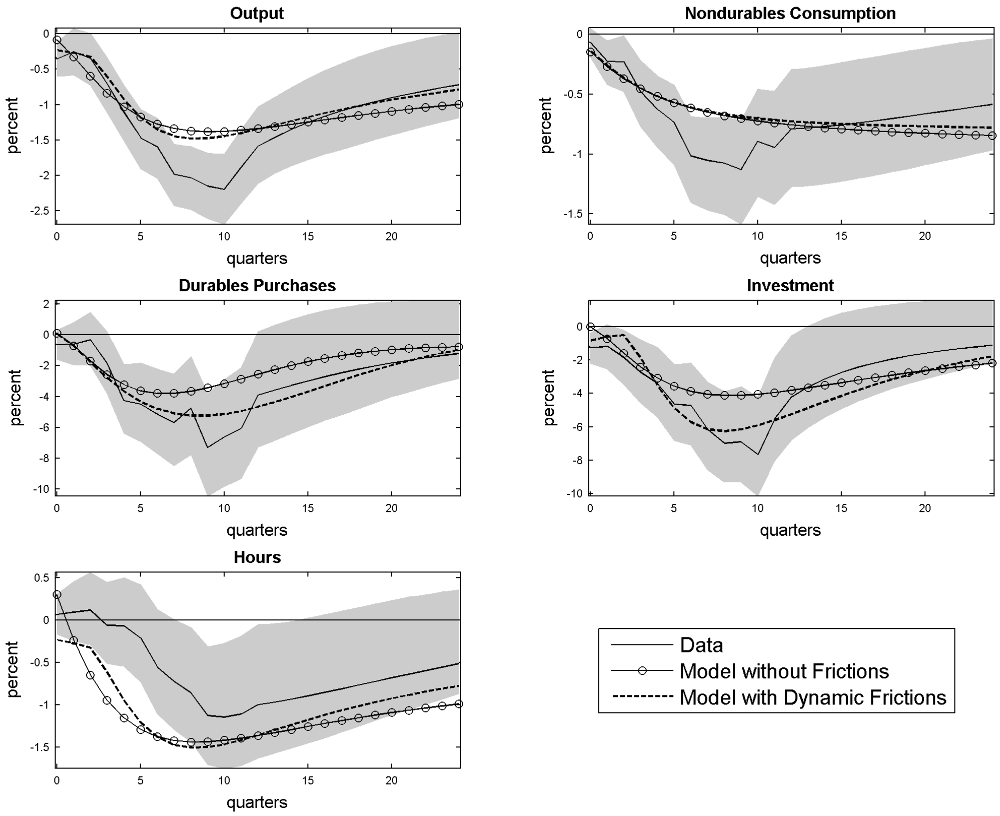
Notes: Estimated dynamics of capital and durables frictions after a shock to capital and labor income taxes.

Specification 1, Case 1. Last but not least, the solid lines and the shaded areas describe the empirical impulse responses with 68 percent confidence bands.

Comparing the results of the benchmark model to Specification 3, we find that the introduction of our additional investment frictions, $f_{k,t}$ and $f_{d,t}$, improves the fit of the model substantially. In the present specification, output and hours worked go down by 1.5 percent at the peak. Strikingly, the model is now able to generate tax multipliers of 5.2 percent for durables purchases and of 6.3 percent for investment.

These findings provide evidence in favor of the hypothesis that additional investment frictions are necessary in our model to match the large empirical tax multipliers for invest-

Figure 2.10: Impulse responses for Specification 3



Notes: Model impulse responses to a shock in capital and labor income taxes in the model with and without dynamic investment frictions. The solid line represents empirical impulse responses, with the shaded areas corresponding to 68 percent confidence intervals.

ment and durables purchases. In the following, we conduct more formal tests to quantify the importance and the size of these frictions.

2.5.4 Quantifying the Importance of the Investment Frictions

The goal of this subsection is to assess the quantitative relevance of the two additional frictions, $f_{k,t}$ and $f_{d,t}$. Specifically, we want to test whether including these investment wedges in the model makes a significant contribution to explaining the large empirical tax multipliers for durables purchases and investment.

Significance Tests

The most straightforward way of determining the statistical importance of the frictions is to compute the standard errors of ξ_k and ξ_d in Specification 3. These parameters pin down the transmission of the tax shock to the additional investment wedges in our model. As reported in Table 2.4, both ξ_k and ξ_d are highly significant. This indicates that they are quantitatively relevant.

We furthermore test whether ξ_k and ξ_d are significantly different from each other. Our null hypothesis is given by $H_0 : \xi_k = \xi_d$ and is tested against the alternative $H_a : \xi_k \neq \xi_d$. This is equivalent to testing $H_0 : \xi_k - \xi_d = 0$.[27] The corresponding Wald test then reads as follows:

$$WALD = \left[\frac{\xi_k - \xi_d}{\sqrt{VAR(\xi_k - \xi_d)}} \right]^2 = \left[\frac{5.38 - 0.23}{\sqrt{4.8405}} \right]^2 = 5.4642$$

The critical value at the five percent level from the χ^2 distribution is equal to 3.8415. Therefore, we reject the null hypothesis that the two coefficients are equal. For the construction of our model, this implies that it is important to consider two separate frictions – one for durables and one for capital investment.

Distance Measures

In a next step, we compare the general fit of the model with and without frictions. For this purpose, we look at the weighted distance between theoretical and empirical impulse responses, denoted by $\mathcal{D}$. Recall the definition of our distance measure from Equation (2.22):

$$\mathcal{D} = \left(\Lambda^m(\Theta_2|\Theta_1) - \hat{\Lambda}^e \right)' W \left(\Lambda^m(\Theta_2|\Theta_1) - \hat{\Lambda}^e \right)$$

The parameters in each specification are estimated such that this expression is minimized. Therefore, we can interpret $\mathcal{D}$ as a measure for the goodness of fit. Intuitively, the smaller it is, the better is the match of a given model. Table 2.5 provides the corresponding values for all three specifications.

Table 2.5: Comparison of goodness of fit

	Value of $\mathcal{D}$
Specification 1	60.02
Specification 2	55.52
Specification 3	39.74

As expected, Specification 3 clearly exhibits the lowest $\mathcal{D}$. The introduction of dynamic frictions improves the fit of the model by more than 33 percent compared to the benchmark specification. This difference is of course smaller for the model with constant frictions.

[27]The variance of this expression is given by: $VAR(\xi_k - \xi_d) = VAR(\xi_k) + VAR(\xi_d) - 2COV(\xi_k, \xi_d)$.

Nevertheless, Specification 2 still reduces the weighted distance between the theoretical and empirical impulse responses by 7.5 percent relative to Specification 1.

Over-Identifying Restriction Test

In order to test whether the difference of $\mathcal{D}$ between Specification 3 and 1 is statistically significant, we conduct an over-identifying restriction test for classical minimum distance estimation as proposed in Chamberlain (1984). In our case, the model with dynamic frictions is the unrestricted model (subscript u, with p parameters to be estimated) and the model without frictions is the restricted model (subscript r, with s parameters to be estimated). The test statistic is given by:

$$\mathcal{D}_r - \mathcal{D}_u \xrightarrow{d} \chi^2(p-s) \tag{2.25}$$

In our case, $p = 16$ and $s = 10$, and the corresponding critical value from the χ^2_6 distribution is given by 10.645. Our test statistic is equal to 20.28. Therefore, we conclude that the model with dynamic frictions fits the data significantly better than the benchmark model.

Note that this finding should be interpreted with caution. The reason is that – as explained in Section 2.4.2 – we use the diagonal instead of the full covariance matrix in order to calculate $\mathcal{D}$. As emphasized by Wooldridge (2010), the test statistic in Equation (2.25), on the other hand, is defined for W being equal to the inverse of the full covariance matrix. Therefore, we see our result only as an approximation. However, the fact that the value of the test statistic is almost twice as large as the critical value is reassuring.

Summary

Based on our findings, we conclude that our additional investment wedges are quantitatively relevant. First of all, the parameters that determine the transmission of tax shocks to our investment frictions, denoted by ξ_k and ξ_d, are highly significant. Second, they are significantly different from each other. Specifically, they are equal to $\xi_k = 5.38$ and $\xi_d = 0.23$ respectively. This implies that it is important to allow for separate capital and durables frictions.

Last but not least, we show that our specification with dynamic frictions reduces the weighted distance between the theoretical and empirical impulse responses by more than 33 percent compared to the benchmark specification. This finding is confirmed by an over-identifying restriction test, which clearly rejects the null hypothesis, indicating that our model in Specification 3 fits the data significantly better than our benchmark.

2.6 Discussion: Interpretation of Investment Frictions

Our analysis documents that a standard model with tax wedges is not able to explain the large empirical tax multipliers for durables purchases and investment. We show that this mismatch can be resolved by introducing two additional wedges for durables and capital investment that are activated by tax changes. Specifically, we find a positive comovement between taxes and these additional frictions. Furthermore, the size of the investment wedge differs significantly for durables and capital investment.

In this section, we discuss the implications of our results. So far, we have not taken a stand on the microfoundations behind our additional investment wedges. In a next step, we therefore explore models that can generate these wedges endogenously. Our findings provide helpful guidance for the choice of the appropriate modeling approach.

Financial Frictions as a Source of Investment Wedges

Models with financial frictions, such as the ones developed by e.g. Carlstrom and Fuerst (1997), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (1999) are obvious candidates for microfoundations because they can generate investment wedges endogenously.[28] This argument is in part motivated by Romer and Romer (2010), who suggest a link between the large empirical tax multiplier for investment and financial conditions. Specifically, they state that the "strong response of investment to tax changes is consistent with research showing that investment depends strongly on cash flow and overall economic conditions" (page 797). In other words, this implies a tightening of financial frictions after a tax increase.[29]

A typical measure for financial frictions is the external finance premium, which is reflected in credit spreads in the data. Thus, if the investment wedges in our model are generated by financial frictions, then empirical credit spreads should also react to tax changes. A credit spread that is especially suitable as a proxy for financial frictions is the excess bond premium (EBP) provided by Gilchrist and Zakrajsek (2011).[30] Figure

---

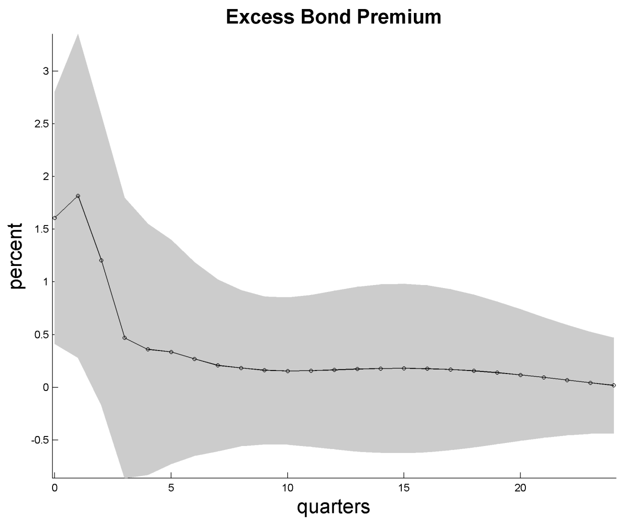
[28]Note that not all models with financial frictions imply an investment wedge. In Christiano and Eichenbaum (1992), Fuerst (1992), Christiano, Eichenbaum, and Evans (1997), Cooley and Quadrini (1999, 2004), Neumeyer and Perri (2005), Schmitz (2005), and Lagos (2006), financial frictions act like a tax on the production of output and therefore, in the notation of Chari, Kehoe, and McGrattan (2007), they constitute an efficiency wedge rather than an investment wedge. For more details, see also the review by Quadrini (2011).

[29]For empirical evidence on financial market imperfections at the firm level, see Fazzari, Hubbard, and Petersen (1988).

[30]As demonstrated by Philippon (2009), credit spreads might react even in the absence of financial frictions simply due to changes in default risk. Therefore, it is crucial that we focus on a spread that is free of this default risk component. EBP is a very suitable measure because it is defined as the component of the GZ spread (recall that we used the GZ spread in our calibration of f_k in steady state in Section

2.11 presents the empirical impulse response of EBP to an increase in unanticipated tax changes by one percent of GDP.[31]

Figure 2.11: Empirical impulse response of EBP



Notes: Empirical impulse response of the excess bond premium for non-financial firms after an increase in tax liabilities by one percent of GDP. The shaded area corresponds to the 95 percent confidence interval.

Interestingly, EBP increases significantly after a tax shock. Since this reaction cannot be driven by a higher default risk (which is per definition excluded from the spread), we interpret it as evidence for the fact that our additional investment wedges might indeed be driven by financial frictions. This point is further strengthened by observing that the dynamics of EBP show striking similarities with the AR(2) process of our capital friction from the model (see Figure 2.9).

Based on these findings, we conclude that the additional investment wedges in our model are likely to be generated by financial frictions.

Implications of Our Results for Models with Financial Frictions

To the extent that the investment wedges in our model are generated by financial frictions, our findings offer guidance for the construction of such models. In the following, we discuss

2.4.1) that cannot be explained by default risk. Therefore, it reflects the willingness of the market to accept default risk. This allows us to interpret it as evidence for financial frictions.

[31] Since EBP is only available from 1973Q1 onwards, we need to deviate from our empirical specification in Equation (2.1) in order to save degrees of freedom. Specifically, we use the framework derived in Kraus and Winter (2015a), which includes one exogenous and three endogenous lags. See Kraus and Winter (2015a) for a detailed description of our approach.

several model features using the prominent model by Bernanke, Gertler, and Gilchrist (1999).

The key mechanism in the 'financial accelerator' model by Bernanke, Gertler, and Gilchrist (1999) is based on the idea of costly state verification by Townsend (1979). In this framework, entrepreneurs finance their projects using a combination of loans and their own net worth. Due to an agency problem between borrowers and lenders, entrepreneurs face an external finance premium. The higher the entrepreneurs' net worth, the lower is this premium. The reason is that higher net worth allows the entrepreneur to finance a larger fraction of the project himself, which in turn mitigates the agency problem. Thus, in this type of models, taxes can have an impact on the external finance premium by affecting net worth.

The effect of taxes in a financial accelerator economy has been explored by e.g. Fernández-Villaverde (2010) in a model with nominal rigidities. He shows that a tax decrease leads to lower inflation, which reduces entrepreneurs' net worth and thus increases the external finance premium. Therefore, in this model, taxes and interest rate spreads are negatively correlated, which is at odds with our findings. Similarly, Strulik (2008) analyzes the impact of different capital income tax changes in a financial accelerator model. He finds that the response of the risk premium depends on the tax instrument considered. Specifically, a private capital income tax cut increases the tax advantage of debt as opposed to equity finance. Therefore, firms choose a higher leverage ratio, which drives up the risk premium charged by banks. The opposite is the case for a corporate income tax change. Thus, depending on the tax instrument considered, this model may generate a negative correlation between tax changes and financial frictions, which is inconsistent with our results. In contrast, a good model should generate a positive comovement between investment wedges and tax shocks. Furthermore, these wedges should be allowed to differ for durables and capital investment.

This latter feature is difficult to model if the agency problem generating the friction operates at the firm level, as is assumed by e.g. Bernanke, Gertler, and Gilchrist (1999) as well as in many other theories of financial frictions. Since durable goods are purchased by households, this kind of model has a hard time explaining changes in the interest rate spreads for durables. We therefore conclude that our evidence supports recent theories that place the friction at the level of financial intermediaries, such as e.g. Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Gertler, Kiyotaki, and Queralto (2012), He and Krishnamurthy (2013), and Brunnermeier and Sannikov (2014). In these models, balance sheets of intermediaries are an important determinant of financial frictions. The link between taxes and intermediaries' balance sheets is consistent with empirical results from our companion paper, Kraus and Winter (2015a).

Contributions

In conclusion, we show that the additional investment wedges in our model can be endogenously generated by financial frictions. Therefore, our findings provide useful guidance for the construction of these models and help researchers choose the appropriate mechanism. Given that there are many different (and competing) modeling approaches for financial frictions, we view this as an important contribution.

According to our results, a good model should generate a positive comovement between investment wedges and tax shocks. Importantly, these wedges should be allowed to differ for durables and capital investment and should operate at the level of financial intermediaries.

2.7 Conclusion

Previous research documents that tax changes have a substantial effect on real economic variables in the data. In this paper, we show that an augmented RBC model with standard tax wedges cannot explain the large empirical tax multipliers for investment and durables purchases. We demonstrate that additional investment wedges are needed in order to bring the model closer to the data. In our quantification exercise, we find that separate wedges for capital and durables investment are necessary and that they are both highly significant. According to our estimates, a tax increase of one percent of GDP triggers an initial rise in the capital and durables friction by 5.4 and 0.2 percentage points respectively. By doing so, our model is able to reproduce the shape and size of the reaction of durables purchases and investment observed in the data. Compared to the benchmark specification with tax wedges only, the introduction of our additional investment wedges improves the fit of the model by more than 33 percent. Thus, our findings indicate that investment wedges are crucial for the modeling of the transmission of tax changes.

By quantifying the additional investment wedges needed in order to match empirical tax multipliers of durables and capital investment, our results provide useful guidance for the construction of models that successfully account for the transmission of tax changes. In our model, we do not take a stand on the microfoundations for these wedges. We leave it to future research to endogenize our capital and durables investment wedges. Nevertheless, we argue that financial frictions are obvious candidates. Based on our findings, we conclude that in that case, the friction should be placed on the level of the financial intermediary, such as e.g. in Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Gertler, Kiyotaki, and Queralto (2012), He and Krishnamurthy (2013), and Brunnermeier and Sannikov (2014). A tax increase should then affect the intermediaries' balance sheets such that financial frictions tighten. In our companion paper, Kraus and

Winter (2015a), we show that empirically, a rise in taxes widens credit spreads, which can be interpreted as an increase in financial frictions. We furthermore show that there is indeed empirical evidence for the fact that tax changes affect balance sheet conditions of financial intermediaries.

As a final remark, we would like to note that the tension between matching the responses of output and hours that is currently present in our model can be mitigated by an additional efficiency wedge that is activated by tax changes. Such a wedge would cause a larger drop in output for a given change in labor supply. Since this extension would primarily affect intratemporal optimality conditions, it would not change our main conclusions, which depend on intertemporal decisions. Future research should also consider modeling the actual tax code in a more realistic manner, e.g. by introducing depreciation allowances (as e.g. in Mertens and Ravn 2011).

2.A Appendix

2.A.1 Model Equations

List of Variables and Parameters

- 16 control variables:[32] $c_t, c_{y,t}, h_t, \lambda_t, p_{d,t}, p_{k,t}, r_t, w_t, q_{k,t}, q_{d,t}, I_t, V_t, TRY_t, T_t, u_t, y_t$
- 16 endogenous state variables: $k_{t-1}, d_{t-1}, d_{t-2}, c_{y,t-1}, r_{t-1}, I_{t-1}, V_{t-1}, B_{t-1}$, $\tau_{k,t-1}, \tau_{k,t-2}, \tau_{n,t-1}, \tau_{n,t-2}, f_{k,t-1}, f_{k,t-2}, f_{d,t-1}, f_{d,t-2}$
- 4 exogenous state variables: $\tau_{k,t}, \tau_{n,t}, f_{k,t}, f_{d,t}$
- Parameters: $\alpha, \beta, \gamma, \delta_k, \delta_d, \nu, \phi, b, g, \tau_k, \tau_n, f_k, f_d, \sigma, \Psi, \pi, a, S_k'', S_d''$, $\rho_{k,1}, \rho_{k,2}, \rho_{n,1}, \rho_{n,2}, \rho_{fk,1}, \rho_{fk,2}, \rho_{fd,1}, \rho_{fd,2}, \xi_k, \xi_d$

List of Equations

Euler equation

with respect to $c_{y,t}$:

$$\lambda_t = [c_t^{-\sigma} - \beta\pi\mathbb{E}_t c_{t+1}^{-\sigma}]\phi\left(\frac{d_{t-1}}{c_{y,t}}\right)^{1-\phi} \tag{2.A.1}$$

with respect to d_{t-1}:

$$\lambda_t = [c_t^{-\sigma} - \beta\pi\mathbb{E}_t c_{t+1}^{-\sigma}]\frac{(1-\phi)}{p_{d,t}}\left(\frac{d_{t-1}}{c_{y,t}}\right)^{-\phi} \tag{2.A.2}$$

with respect to B_t:

$$\lambda_t = \mathbb{E}_t\lambda_{t+1}[1 + (1-\tau_{k,t+1})r_t]\beta \tag{2.A.3}$$

Labor-leisure choice:

$$\lambda_t = \frac{\gamma h_t^{\Psi}}{(1-\tau_{n,t})w_t} \tag{2.A.4}$$

Definition of composite consumption:

$$c_t = c_{y,t}^{\phi} d_{t-1}^{1-\phi} - \pi c_{y,t-1}^{\phi} d_{t-2}^{1-\phi} \tag{2.A.5}$$

Technology for final good production:

$$y_t = \nu(u_t k_{t-1})^{\alpha} h_t^{1-\alpha} \tag{2.A.6}$$

[32]Note that for simplicity, we define $TRY_t \equiv \frac{TR_t}{y_t}$ in the Appendix.

Final good producers' FOC(k):

$$p_{k,t} = \nu\alpha(u_t k_{t-1})^{\alpha-1} h_t^{1-\alpha} \tag{2.A.7}$$

Final good producers' FOC(h):

$$w_t = \nu(1-\alpha)(u_t k_{t-1})^{\alpha} h_t^{-\alpha} \tag{2.A.8}$$

Choice of capacity utilization by capital good traders:

$$p_{k,t} = \Omega'(u_t) q_{k,t} \tag{2.A.9}$$

where
$\Omega(u_t) = \frac{1}{2} b a u_t^2 + b(1-a)u_t + b(\frac{a}{2} - 1)$ and
$\Omega'(u_t) = b a u_t + b(1-a)$

Rental price for capital:

$$\mathbb{E}_t p_{k,t+1} u_{t+1} = (1 + r_t + f_{k,t}) q_{k,t} - \mathbb{E}_t (1 - \delta_k - \Omega(u_{t+1})) q_{k,t+1} \tag{2.A.10}$$

Rental price for durables:

$$\mathbb{E}_t p_{d,t+1} = (1 + r_t + f_{d,t}) q_{d,t} - (1 - \delta_d) \mathbb{E}_t q_{d,t+1} \tag{2.A.11}$$

Price of installed capital:

$$1 - q_{k,t}\left[1 - S_k\left(\frac{I_t}{I_{t-1}}\right) - S_k'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right] = \beta\mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} q_{k,t+1} S_k'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2 \tag{2.A.12}$$

Price of installed durables:

$$1 - q_{d,t}\left[1 - S_d\left(\frac{V_t}{V_{t-1}}\right) - S_d'\left(\frac{V_t}{V_{t-1}}\right)\frac{V_t}{V_{t-1}}\right] = \beta\mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} q_{d,t+1} S_d'\left(\frac{V_{t+1}}{V_t}\right)\left(\frac{V_{t+1}}{V_t}\right)^2 \tag{2.A.13}$$

Law of motion for capital:

$$k_t = (1 - \delta_k - \Omega(u_t)) k_{t-1} + [1 - S_k\left(\frac{I_t}{I_{t-1}}\right)] I_t \tag{2.A.14}$$

Law of motion for durables:

$$d_t = (1-\delta_d)d_{t-1} + [1 - S_d\left(\frac{V_t}{V_{t-1}}\right)]V_t \tag{2.A.15}$$

where
$S\left(m_t\right) = \frac{1}{2}\left\{\exp\left[\sqrt{S''}\left(m_t-1\right)\right] + \exp\left[-\sqrt{S''}\left(m_t-1\right)\right] - 2\right\}$
$S'(m_t) = \frac{1}{2}\left\{\exp\left[\sqrt{S''}\left(m_t-1\right)\right]\sqrt{S''} + \exp\left[-\sqrt{S''}\left(m_t-1\right)\right]\left(-\sqrt{S''}\right)\right\}$

Good market clearing:

$$y_t = c_{y,t} + I_t + S_k\left(\frac{I_t}{I_{t-1}}\right)I_t + V_t + S_d\left(\frac{V_t}{V_{t-1}}\right)V_t + G \tag{2.A.16}$$

The state $c_{y,t-1}$ in the next period is equal to the corresponding control in this period:

$$c_{y,t} = c_{y,t} \tag{2.A.17}$$

The state d_{t-2} in the next period is equal to the corresponding control in this period:

$$d_{t-1} = d_{t-1} \tag{2.A.18}$$

The state r_{t-1} in the next period is equal to the corresponding control in this period:

$$r_t = r_t \tag{2.A.19}$$

The state I_{t-1} in the next period is equal to the corresponding control in this period:

$$I_t = I_t \tag{2.A.20}$$

The state V_{t-1} in the next period is equal to the corresponding control in this period:

$$V_t = V_t \tag{2.A.21}$$

The state $\tau_{k,t-1}$ in the next period is equal to the corresponding state in this period:

$$\tau_{k,t} = \tau_{k,t} \tag{2.A.22}$$

The state $\tau_{n,t-1}$ in the next period is equal to the corresponding state in this period:

$$\tau_{n,t} = \tau_{n,t} \tag{2.A.23}$$

The state $f_{k,t-1}$ in the next period is equal to the corresponding state in this period:

$$f_{k,t} = f_{k,t} \tag{2.A.24}$$

The state $f_{d,t-1}$ in the next period is equal to the corresponding state in this period:

$$f_{d,t} = f_{d,t} \tag{2.A.25}$$

Definition of bonds:

$$B_t = k_t q_{k,t} + d_t q_{d,t} \tag{2.A.26}$$

Transfers from government to households:

$$T_t = \tau_{n,t} w_t h_t + \tau_{k,t} r_{t-1} B_{t-1} - G \tag{2.A.27}$$

where $G = g \cdot \bar{y}$

Definition of tax revenues over GDP:[33]

$$TRY_t = \frac{T_t + G}{y_t} \tag{2.A.28}$$

Law of motion for capital taxes:

$$\tau_{k,t} = (1 - \rho_{k,1} - \rho_{k,2})\tau_k + \rho_{k,1}\tau_{k,t-1} + \rho_{k,2}\tau_{k,t-2} + \varepsilon_t^k \tag{2.A.29}$$

Law of motion for labor taxes:

$$\tau_{n,t} = (1 - \rho_{n,1} - \rho_{n,2})\tau_n + \rho_{n,1}\tau_{n,t-1} + \rho_{n,2}\tau_{n,t-2} + \varepsilon_t^n \tag{2.A.30}$$

Law of motion for capital friction:

$$f_{k,t} = (1 - \rho_{fk,1} - \rho_{fk,2}) f_k + \rho_{fk,1} f_{k,t-1} + \rho_{fk,2} f_{k,t-2} + \varepsilon_{fk,t} \tag{2.A.31}$$

[33]According to Hall (2011), page 358: "GDP includes both the services of housing as a component of consumption and the production of houses, as a component of investment. Here, output is the production of goods, which are used to make houses or are consumed directly." Mertens and Ravn (2011) just define tax revenues over GDP as tax revenues over final output, regardless of the level of durables. The difference between Mertens and Ravn (2011) and Hall (2011) is that the latter interprets durables as housing and the former interpret durables in the classical sense (also in the way they are defined in the data). In our model, we therefore follow the definition by Mertens and Ravn (2011).

Law of motion for durables friction:

$$f_{d,t} = (1 - \rho_{fd,1} - \rho_{fd,2})f_d + \rho_{fd,1}f_{d,t-1} + \rho_{fd,2}f_{d,t-2} + \varepsilon_{fd,t} \tag{2.A.32}$$

Steady State

We normalize output and capacity utilization to 1 and hours to 25 percent in steady state.

Steady state for y:

$$\underline{\underline{\bar{y} = 1}}$$

Steady state for h:

$$\underline{\underline{\bar{h} = 0.25}}$$

Steady state for u:

$$\underline{\underline{\bar{u} = 1}}$$

Euler equation, determines r:

$$1 = \beta[1 + (1 - \tau_k)\bar{r}]$$

Steady state for r:

$$\underline{\underline{\bar{r} = \frac{1-\beta}{\beta}\frac{1}{1-\tau_k}}}$$

Steady state for q_k:

$$\underline{\underline{\bar{q}_k = 1}}$$

Steady state for q_d:

$$\underline{\underline{\bar{q}_d = 1}}$$

Steady state for p_k:

$$\underline{\underline{\bar{p}_k = (\bar{r} + f_k + \delta_k)\bar{q}_k}}$$

Choice of capacity utilization by capital good traders:

$$\bar{p}_k = \Omega'(\bar{u})\bar{q}_k = b\bar{q}_k$$

Parameter value of b:

$$\underline{\underline{b = \frac{\bar{p}_k}{\bar{q}_k}}}$$

Steady state for p_d:

$$\underline{\underline{\bar{p}_d = (\bar{r} + f_d + \delta_d)\bar{q}_d}}$$

The Euler equation determines the consumption basket. We target a share of durables consumption in steady state of 11.9 percent.

$$\frac{\bar{d}}{\bar{c}_y} = \frac{1-\phi}{\bar{p}_d\phi} = \frac{0.119}{1-0.119} = 0.1351$$

This allows us to solve for ϕ.

Parameter value of ϕ:

$$\underline{\underline{\phi = \frac{1}{1 + 0.1351p_d}}}$$

Combining the final good producers' production function and $FOC(k)$ allows us to solve for $\bar{k}$ and ν.

Steady state for k:

$$\underline{\underline{\bar{k} = \frac{\alpha}{\bar{p}_k}}}$$

Parameter value of ν:

$$\underline{\underline{\nu = \frac{1}{\bar{k}^{\alpha}\bar{h}^{1-\alpha}}}}$$

From the final good producers' production function and $FOC(h)$, we get the wage in steady state.

Steady state for w:

$$\underline{\underline{\bar{w} = \nu(1-\alpha)\left(\frac{\bar{k}}{\bar{h}}\right)^{\alpha}}}$$

The laws of motion of capital and durables determine capital and durables investment respectively.

Steady state for I:

$$\underline{\underline{\bar{I} = \delta_k\bar{k}}}$$

The steady state for V is given by $\bar{V} = \delta_d\bar{d}$. However, we first need to determine $\bar{d}$. We do so by using the equation for good market clearing, which only depends on variables that can be expressed as a function of $\bar{d}$ and variables with a steady state that we have already determined:

$$\bar{y} = \underbrace{\bar{c}_y}_{=\frac{\phi\bar{p}_d}{1-\phi}\bar{d}} + \bar{I} + \underbrace{S^k\left(\frac{\bar{I}}{\bar{I}}\right)}_{=0}\bar{I} + \underbrace{\bar{V}}_{=\delta_d\bar{d}} + \underbrace{S^d\left(\frac{\bar{V}}{\bar{V}}\right)}_{=0}\bar{V} + \underbrace{G}_{=g\bar{y}}$$

This allows us to solve the good market clearing condition for d in steady state.

Steady state for d:

$$\underline{\underline{\bar{d} = \frac{(1-g)\bar{y} - \bar{I}}{\delta_d + \frac{\phi\bar{p}_d}{1-\phi}}}}$$

Steady state for V:

$$\underline{\underline{\bar{V} = \delta_d\bar{d}}}$$

Steady state for c_y:

$$\underline{\underline{\bar{c}_y = \frac{\phi\bar{p}_d}{1-\phi}\bar{d}}}$$

Steady state for c:

$$\underline{\underline{\bar{c} = \bar{c}_y^{\phi}\bar{d}^{1-\phi}(1-\pi)}}$$

The Euler equation allows us to determine the parameter γ, which is set such that $\bar{h} = 0.25$.

Parameter value of γ:

$$\underline{\underline{\gamma = (1-\beta\pi)\bar{c}^{-\sigma}\phi\left(\frac{\bar{d}}{\bar{c}_y}\right)^{1-\phi}(1-\tau_n)\bar{w}\bar{h}^{-\Psi}}}$$

Steady state for λ:

$$\underline{\underline{\bar{\lambda} = (1-\beta\pi)\bar{c}^{-\sigma}\phi\left(\frac{\bar{d}}{\bar{c}_y}\right)^{1-\phi}}}$$

2.A.2 Log-Linearized Equations

In order to solve our model, we need to log-linearize it. First of all, define $\hat{x} \equiv \ln\left(\frac{x_t}{\bar{x}}\right)$ and $\hat{x}$ can be interpreted as the percent deviation from steady state. We use the following rule:

$$f(x, y) = 0$$

becomes:

$$\hat{x}\left[\frac{\partial f(\bar{x},\bar{y})}{\partial x}\bar{x}\right]+\hat{y}\left[\frac{\partial f(\bar{x},\bar{y})}{\partial y}\bar{y}\right]\backsimeq 0$$

In order to simplify the resulting log-linearized equations, it is often useful to divide both sides by the steady state.

List of Equations

Euler equation

with respect to $c_{y,t}$:

$$[\beta\pi\mathbb{E}_t\hat{c}_{t+1}-\hat{c}_t]\frac{\sigma}{1-\beta\pi}+[\hat{d}_{t-1}-\hat{c}_{y,t}](1-\phi)-\hat{\lambda}_t=0 \tag{2.A.33}$$

with respect to d_{t-1}:

$$[\beta\pi\mathbb{E}_t\hat{c}_{t+1}-\hat{c}_t]\frac{\sigma}{1-\beta\pi}-[\hat{d}_{t-1}-\hat{c}_{y,t}]\phi-\hat{p}_d-\hat{\lambda}_t=0 \tag{2.A.34}$$

with respect to B_t:

$$\mathbb{E}_t\hat{\lambda}_{t+1}-\mathbb{E}_t\hat{\tau}_{k,t+1}\bar{\tau}_k\bar{r}\beta+\hat{r}_t\bar{r}(1-\bar{\tau}_k)\beta-\hat{\lambda}_t=0 \tag{2.A.35}$$

Labor-leisure choice:

$$\hat{h}_t\Psi+\hat{\tau}_{n,t}\frac{\bar{\tau}_n}{1-\bar{\tau}_n}-\hat{w}_t-\hat{\lambda}_t=0 \tag{2.A.36}$$

Definition of composite consumption:

$$\hat{c}_t-\frac{1}{1-\pi}[\phi(\hat{c}_{y,t}-\pi\hat{c}_{y,t-1})+(1-\phi)(\hat{d}_{t-1}-\pi\hat{d}_{t-2})]=0 \tag{2.A.37}$$

Technology for final good production:

$$\hat{y}_t-\alpha(\hat{u}_t+\hat{k}_{t-1})-(1-\alpha)\hat{h}_t=0 \tag{2.A.38}$$

Final good producers' FOC(k):

$$\hat{p}_{k,t}+(1-\alpha)[\hat{u}_t+\hat{k}_{t-1}-\hat{h}_t]=0 \tag{2.A.39}$$

Final good producers' FOC(h):

$$\hat{w}_t - \alpha[\hat{u}_t + \hat{k}_{t-1} - \hat{h}_t] = 0 \tag{2.A.40}$$

Choice of capacity utilization by capital good traders:

$$\hat{p}_{k,t} - \hat{q}_{k,t} - \hat{u}_t a = 0 \tag{2.A.41}$$

Rental price for capital:

$$\mathbb{E}_t \hat{p}_{k,t+1}\bar{p}_k - \hat{q}_{k,t}\bar{q}_k(1 + \bar{r} + \bar{f}_k) + \mathbb{E}_t \hat{q}_{k,t+1}\bar{q}_k(1 - \delta_k) - \hat{r}_t\bar{r}\bar{q}_k - \hat{f}_{k,t}\bar{f}_k\bar{q}_k = 0 \tag{2.A.42}$$

Rental price for durables:

$$\mathbb{E}_t \hat{p}_{d,t+1}\bar{p}_d - \hat{q}_{d,t}\bar{q}_d(1 + \bar{r} + \bar{f}_d) + \mathbb{E}_t \hat{q}_{d,t+1}\bar{q}_d(1 - \delta_d) - \hat{r}_t\bar{r}\bar{q}_d - \hat{f}_{d,t}\bar{f}_d\bar{q}_d = 0 \tag{2.A.43}$$

Price of installed capital:

$$\hat{q}_{k,t} + S_k''[\hat{I}_{t-1} - (1+\beta)\hat{I}_t + \beta\mathbb{E}_t\hat{I}_{t+1}] = 0 \tag{2.A.44}$$

Price of installed durables:

$$\hat{q}_{d,t} + S_d''[\hat{V}_{t-1} - (1+\beta)\hat{V}_t + \beta\mathbb{E}_t\hat{V}_{t+1}] = 0 \tag{2.A.45}$$

Law of motion for capital:

$$\hat{k}_t\bar{k} - \hat{k}_t\bar{k}\,(1 - \delta_k) - \hat{I}_t\bar{I} + \hat{u}_{t-1}b\bar{k} = 0 \tag{2.A.46}$$

Law of motion for durables:

$$\hat{d}_t\bar{d} - \hat{d}_{t-1}\bar{d}(1 - \delta_d) - \hat{V}_t\bar{V} = 0 \tag{2.A.47}$$

Good market clearing:

$$\hat{y}_t\bar{y} - \hat{c}_{y,t}\bar{c}_y - \hat{I}_t\bar{I} - \hat{V}_t\bar{V} = 0 \tag{2.A.48}$$

The state $\hat{c}_{y,t-1}$ in the next period is equal to the corresponding control in this period:

$$\hat{c}_{y,t} = \hat{c}_{y,t} \tag{2.A.49}$$

The state $\hat{d}_{t-2}$ in the next period is equal to the corresponding control in this period:

$$\hat{d}_{t-1} = \hat{d}_{t-1} \tag{2.A.50}$$

The state $\hat{r}_{t-1}$ in the next period is equal to the corresponding control in this period:

$$\hat{r}_t = \hat{r}_t \tag{2.A.51}$$

The state $\hat{I}_{t-1}$ in the next period is equal to the corresponding control in this period:

$$\hat{I}_t = \hat{I}_t \tag{2.A.52}$$

The state $\hat{V}_{t-1}$ in the next period is equal to the corresponding control in this period:

$$\hat{V}_t = \hat{V}_t \tag{2.A.53}$$

The state $\hat{\tau}_{k,t-1}$ in the next period is equal to the corresponding state in this period:

$$\hat{\tau}_{k,t} = \hat{\tau}_{k,t} \tag{2.A.54}$$

The state $\hat{\tau}_{n,t-1}$ in the next period is equal to the corresponding state in this period:

$$\hat{\tau}_{n,t} = \hat{\tau}_{n,t} \tag{2.A.55}$$

The state $\hat{f}_{k,t-1}$ in the next period is equal to the corresponding state in this period:

$$\hat{f}_{k,t} = \hat{f}_{k,t} \tag{2.A.56}$$

The state $\hat{f}_{d,t-1}$ in the next period is equal to the corresponding state in this period:

$$\hat{f}_{d,t} = \hat{f}_{d,t} \tag{2.A.57}$$

Definition of B_t:

$$\hat{B}_t\bar{B} - \bar{k}\bar{q}_k[\hat{k}_t + \hat{q}_{k,t}] - \bar{d}\bar{q}_d[\hat{d}_t + \hat{q}_{d,t}] = 0 \tag{2.A.58}$$

Transfers from government to households:

$$\hat{T}_t\bar{T} - \bar{\tau}_n\bar{w}\bar{h}[\hat{\tau}_{n,t} + \hat{w}_t + \hat{h}_t] - \bar{\tau}_k\bar{r}\bar{B}[\hat{\tau}_{k,t} + \hat{r}_{t-1} + \hat{B}_{t-1}] = 0 \tag{2.A.59}$$

where $\hat{G} = 0 \quad \forall t$

Definition of tax revenues over GDP:

$$\widehat{TRY}_t - \widehat{T}_t \frac{\overline{T}}{\overline{T}+G} + \hat{y}_t = 0 \tag{2.A.60}$$

For the log-linearization of the law of motions of our exogenous state variables, we use the fact that $\hat{x} \approx \frac{x-\bar{x}}{\bar{x}}$. Note that the error term, ε, is not in log-linear terms.

Law of motion for capital taxes:

$$\hat{\tau}_{k,t} = \rho_{k,1}\hat{\tau}_{k,t-1} + \rho_{k,2}\hat{\tau}_{k,t-2} + \varepsilon_t^k \tag{2.A.61}$$

Law of motion for labor taxes:

$$\hat{\tau}_{n,t} = \rho_{n,1}\hat{\tau}_{n,t-1} + \rho_{n,2}\hat{\tau}_{n,t-2} + \varepsilon_t^n \tag{2.A.62}$$

Law of motion for capital friction:

$$\hat{f}_{k,t} = \rho_{fk,1}\hat{f}_{k,t-1} + \rho_{fk,2}\hat{f}_{k,t-2} + \varepsilon_{fk,t} \tag{2.A.63}$$

Law of motion for durables friction:

$$\hat{f}_{d,t} = \rho_{fd,1}\hat{f}_{d,t-1} + \rho_{fd,2}\hat{f}_{d,t-2} + \varepsilon_{fd,t} \tag{2.A.64}$$

2.A.3 Functional Form Assumptions

Utilization Costs

The utilization cost function is defined as in Christiano, Trabandt, and Walentin (2010):

$$\begin{aligned}
&\Omega(u_t) = \frac{1}{2}bau_t^2 + b(1-a)u_t + b(\frac{a}{2}-1) \\
&with \quad \Omega(1) = 0 \quad and \quad \Omega', \Omega'' \geq 0 \\
&and \quad b = \Omega'(1) \quad and \quad a = \frac{\Omega''(1)}{\Omega'(1)} \quad for \quad u \geq 0
\end{aligned}$$

The parameter a determines the curvature of Ω. If a is close to zero, it is easy to change utilization.

Adjustment Costs

Following Christiano, Trabandt, and Walentin (2010), we assume that the functional form of adjustment costs is given by:

$$S\left(m_t\right) = \frac{1}{2}\left\{\exp\left[\sqrt{S''}\left(m_t - 1\right)\right] + \exp\left[-\sqrt{S''}\left(m_t - 1\right)\right] - 2\right\}$$

where $m_t \equiv \frac{I_t}{I_{t-1}}$ for capital good producers and $m_t \equiv \frac{V_t}{V_{t-1}}$ for durable good producers. I denotes investment in capital, and V stands for investment in durables. Furthermore, we allow the parameters of the adjustment costs for capital and durable good producers to be different: S_k and S_d have parameters S''_k and S''_d respectively, where S'' is defined as the second derivative of $S(m_t)$ evaluated at $m_t = 1$. The first derivative of S with respect to m_t is equal to:

$$\frac{\partial S(m_t)}{\partial m_t} = \frac{1}{2}\left\{\exp\left[\sqrt{S''}\left(m_t - 1\right)\right]\sqrt{S''} + \exp\left[-\sqrt{S''}\left(m_t - 1\right)\right]\left(-\sqrt{S''}\right)\right\} \equiv S'(m_t)$$

Note that in steady state, $m_t = 1$ and $S(1) = S'(1) = 0$.

2.A.4 Initial Innovations

In this section, we describe the calibration of the initial tax and friction innovations in the model in $t = 0$.

Tax Innovations

Recall that our tax rates follow an AR(2) process:

$$\tau_{k,t} = (1 - \rho_{k,1} - \rho_{k,2})\tau_k + \rho_{k,1}\tau_{k,t-1} + \rho_{k,2}\tau_{k,t-2} + \varepsilon_t^k$$
$$\tau_{n,t} = (1 - \rho_{n,1} - \rho_{n,2})\tau_n + \rho_{n,1}\tau_{n,t-1} + \rho_{n,2}\tau_{n,t-2} + \varepsilon_t^n$$

where τ_k and τ_n without time subscripts denote steady state tax rates.

Following Mertens and Ravn (2011), our benchmark specification assumes that both tax innovations are affected equally by the change in tax revenues, i.e. $\varepsilon_0^k = \varepsilon_0^n$. Specifically, the initial tax shock is chosen such that tax revenues over final output (TRY_0 in our model)[34] increase by one percentage point. This is done by increasing capital and labor tax rates by exactly the same percentage point amount, i.e. $\tau_{k,0} - \tau_k = \tau_{n,0} - \tau_n$. The corresponding levels of $\varepsilon_0^k = \varepsilon_0^n$ as well as the initial tax rates $\hat{\tau}_{k,0}$ and $\hat{\tau}_{n,0}$ in the log-linear

[34] For simplicity, we define $TRY_t \equiv \frac{TR_t}{y_t}$ in the Appendix.

version of our model are derived below. We start by pointing out that the solution of our model is of the following form:

Solution that determines endogenous states $\hat{x}(t)$:

$$\hat{x}(t) = PP\hat{x}(t-1) + QQ\hat{z}(t) \tag{2.A.65}$$

Solution that determines controls $\hat{y}(t)$:

$$\hat{y}(t) = RR\hat{x}(t-1) + SS\hat{z}(t) \tag{2.A.66}$$

Note that all variables in the vectors $\hat{x}(t)$, $\hat{y}(t)$, and $\hat{z}(t)$ are log-linear and therefore can be interpreted as deviations from their steady state. $\hat{z}(t)$ denotes the vector of exogenous states, which includes capital and labor income tax rates. Tax revenues over final output, on the other hand, are part of the $\hat{y}(t)$ vector. Assuming that in time $t = 0$, all variables are in their steady state (i.e. the log-linear version of them is equal to zero), we get an equation that determines $\widehat{TRY}_0$ as a function of taxes:

$$\widehat{TRY}_0 = SS_1\hat{\tau}_{k,0} + SS_2\hat{\tau}_{n,0}$$

where SS_i is the i-th element of the SS vector from the policy function (2.A.66).

As mentioned above, our initial tax shock is assumed to raise tax revenues over final output by one percentage point. Starting from the steady state $\overline{TRY}$, this means that $TRY_0 = \overline{TRY} + 0.01$. The log-linear version of the variable is given by $\widehat{TRY}_0 = ln\left(\frac{\overline{TRY}+0.01}{\overline{TRY}}\right)$. In a next step, we need to calculate the increase in the two tax rates that is consistent with this $\widehat{TRY}_0$. Recall that we assumed $\varepsilon_{k,0} = \tau_{k,0} - \tau_k = \tau_{n,0} - \tau_n = \varepsilon_{n,0}$. Rewriting this condition in log-linear form yields:

$$\underbrace{\frac{\tau_{k,0} - \tau_k}{\tau_k}}_{=\hat{\tau}_{k,0}}\tau_k = \underbrace{\frac{\tau_{n,0} - \tau_n}{\tau_n}}_{=\hat{\tau}_{n,0}}\tau_n$$

Solving this for $\hat{\tau}_{n,0}$ and substituting it into the function for $\widehat{TRY}_0$ leaves us with:

$$\widehat{TRY}_0 = SS_1\hat{\tau}_{k,0} + SS_2\underbrace{\hat{\tau}_{k,0}\frac{\tau_k}{\tau_n}}_{=\hat{\tau}_{n,t}}$$

Solving for $\hat{\tau}_{k,0}$ yields:

$$\hat{\tau}_{k,0} = \frac{\widehat{TRY}_0}{SS_1 + SS_2 \frac{\tau_k}{\tau_n}} = \underbrace{\frac{ln\left(\frac{\overline{TRY}+0.01}{\overline{TRY}}\right)}{\frac{SS_1}{\tau_k} + \frac{SS_2}{\tau_n}}}_{=\varepsilon_0^k} \frac{1}{\tau_k} = \frac{\varepsilon_0^k}{\tau_k}$$

By symmetry:

$$\hat{\tau}_{n,0} = \underbrace{\frac{ln\left(\frac{\overline{TRY}+0.01}{\overline{TRY}}\right)}{\frac{SS_1}{\tau_k} + \frac{SS_2}{\tau_n}}}_{\equiv\varepsilon_0^n} \frac{1}{\tau_n} = \frac{\varepsilon_0^n}{\tau_n}$$

and

$$\varepsilon_0^k = \varepsilon_0^n = \frac{ln\left(\frac{\overline{TRY}+0.01}{\overline{TRY}}\right)}{\frac{SS_1}{\tau_k} + \frac{SS_2}{\tau_n}}$$

Investment Friction Innovations

Recall that our frictions follow an AR(2) process:

$$\begin{aligned} f_{k,t} &= (1 - \rho_{fk,1} - \rho_{fk,2}) f_k + \rho_{fk,1} f_{k,t-1} + \rho_{fk,2} f_{k,t-2} + \varepsilon_{fk,t} \\ f_{d,t} &= (1 - \rho_{fd,1} - \rho_{fd,2}) f_d + \rho_{fd,1} f_{d,t-1} + \rho_{fd,2} f_{d,t-2} + \varepsilon_{fd,t} \end{aligned}$$

We assume that the friction innovations in $t = 0$ react to a tax shock in the following way:

$$\begin{aligned} \varepsilon_{fk,0} &= \xi_k \left(TRY_0 - \overline{TRY}\right) = \xi_k \cdot 0.01 \\ \varepsilon_{fd,0} &= \xi_d \left(TRY_0 - \overline{TRY}\right) = \xi_d \cdot 0.01 \end{aligned}$$

In a next step, we derive the corresponding initial values of the log-linear frictions $\hat{f}_{k,0}$ and $\hat{f}_{d,0}$. For this purpose, we start from the following relationship:

$$\varepsilon_{fk,0} = f_{k,0} - f_k = \xi_k \cdot 0.01$$

and in log-linear terms:

$$\hat{f}_{k,0} \equiv \ln\left[\frac{f_{k,0}}{f_k}\right] = \ln\left[\frac{\xi_k \cdot 0.01 + f_k}{f_k}\right] = \ln\left[1 + \frac{\xi_k \cdot 0.01}{f_k}\right]$$

By symmetry, the initial shock to the durables friction is equal to (assuming that we start in steady state):

$$\varepsilon_{fd,0} = f_{d,0} - f_d = \xi_d \cdot 0.01$$

and the initial durables friction in log-linear terms:

$$\hat{f}_{d,0} \equiv \ln\left[\frac{f_{d,0}}{f_d}\right] = \ln\left[\frac{\xi_d \cdot 0.01 + f_d}{f_d}\right] = \ln\left[1 + \frac{\xi_d \cdot 0.01}{f_d}\right]$$

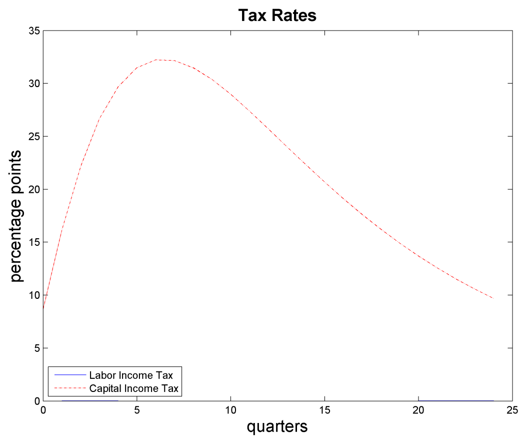
2.A.5 Tables and Figures

Table 2.A.1: Coefficient estimates for Specification 1, Case 2

Parameter	**Explanation**	**Value**	**Standard Error**
σ	Consumption curvature	1.00	(1.57)
Ψ	Hours curvature	0.50	(0.87)
γ	Weight of hours	9.36^c	
π	Habit parameter	0.98***	(0.03)
ϕ	Composite consumption	0.99^c	
ν	Final good production function	1.08^c	
a	Capital utilization parameter	1573559208	(-)
b	Capital utilization parameter	0.04^c	
S''_k	Capital adjustment costs	45.05**	(21.92)
S''_d	Durables adjustment costs	39.86*	(22.85)
$\rho_{k,1}$	AR(2) for capital taxes	1.74***	(0.12)
$\rho_{k,2}$	AR(2) for capital taxes	-0.75***	(0.12)
$\rho_{n,1}$	AR(2) for labor taxes	-	
$\rho_{n,2}$	AR(2) for labor taxes	-	
$\rho_{fk,1}$	AR(2) for capital friction	-	
$\rho_{fk,2}$	AR(2) for capital friction	-	
$\rho_{fd,1}$	AR(2) for durables friction	-	
$\rho_{fd,2}$	AR(2) for durables friction	-	
ξ_k	Initial response of capital friction	-	
ξ_d	Initial response of durables friction	-	
f_k	Steady state capital friction	0^c	
f_d	Steady state durables friction	0^c	

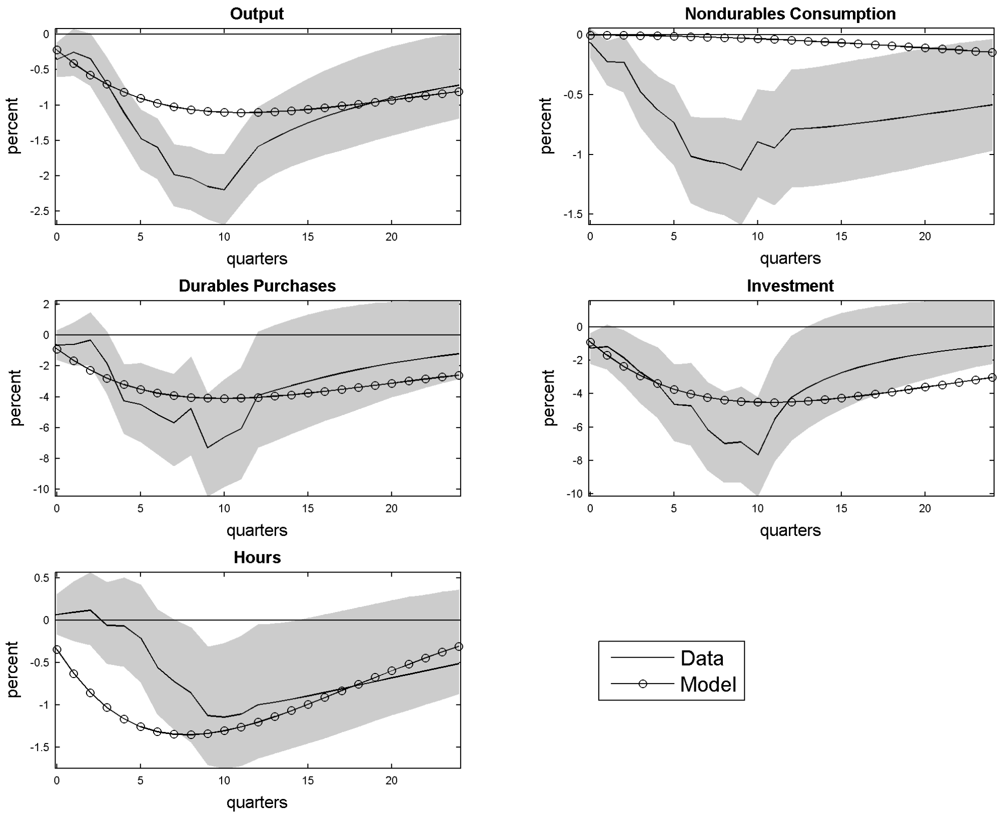
Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. c marks parameters that are not estimated because they are calibrated in steady state. n marks parameters that hit a natural bound.

Figure 2.A.1: Taxes in Specification 1, Case 2



Notes: Estimated dynamics of the capital income tax rate in the model without investment frictions.

Figure 2.A.2: Impulse responses for Specification 1, Case 2



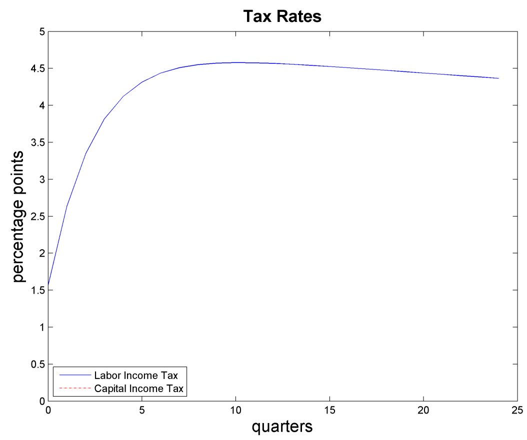
Notes: Model impulse responses to a shock in capital income taxes in the model without investment frictions. The solid line represents empirical impulse responses, with the shaded areas corresponding to 68 percent confidence intervals.

Table 2.A.2: Coefficient estimates for Specification 1, Case 3

Parameter	**Explanation**	**Value**	**Standard Error**
σ	Consumption curvature	3.15***	(0.06)
Ψ	Hours curvature	2.27***	(0.19)
γ	Weight of hours	14373	
π	Habit parameter	0.84***	(0.00)
ϕ	Composite consumption	0.99^c	
ν	Final good production function	1.08^c	
a	Capital utilization parameter	0^n	
b	Capital utilization parameter	0.04^c	
S_k''	Capital adjustment costs	0.72***	(0.09)
S_d''	Durables adjustment costs	0.75***	(0.06)
$\rho_{k,1}$	AR(2) for capital taxes	-	
$\rho_{k,2}$	AR(2) for capital taxes	-	
$\rho_{n,1}$	AR(2) for labor taxes	1.65***	(0.01)
$\rho_{n,2}$	AR(2) for labor taxes	-0.65***	(0.01)
$\rho_{fk,1}$	AR(2) for capital friction	-	
$\rho_{fk,2}$	AR(2) for capital friction	-	
$\rho_{fd,1}$	AR(2) for durables friction	-	
$\rho_{fd,2}$	AR(2) for durables friction	-	
ξ_k	Initial response of capital friction	-	
ξ_d	Initial response of durables friction	-	
f_k	Steady state capital friction	0^c	
f_d	Steady state durables friction	0^c	

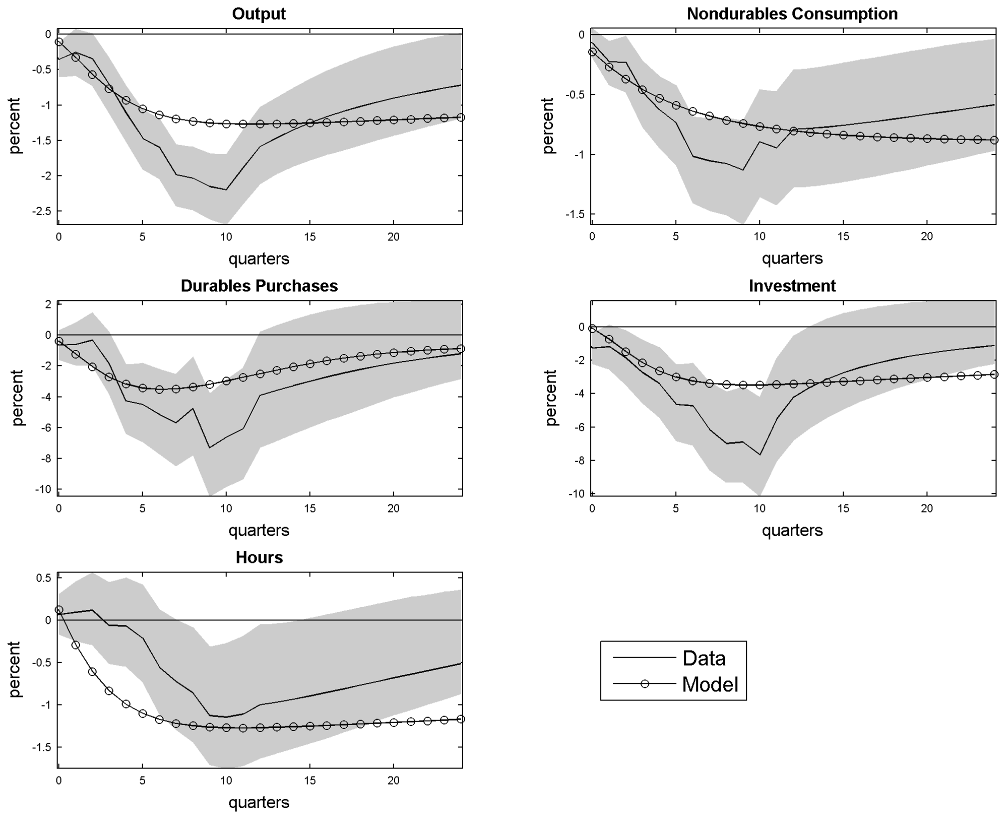
Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. c marks parameters that are not estimated because they are calibrated in steady state. n marks parameters that hit a natural bound.

Figure 2.A.3: Taxes in Specification 1, Case 3



Notes: Estimated dynamics of the labor income tax rate in the model without investment frictions.

Figure 2.A.4: Impulse responses for Specification 1, Case 3



Notes: Model impulse responses to a shock in labor income taxes in the model without investment frictions. The solid line represents empirical impulse responses, with the shaded areas corresponding to 68 percent confidence intervals.

2.A.6 Robustness Check

The parameters that differ the most between Specification 3 and our benchmark case in Specification 1 are σ and S_k''. In particular, in Specification 3, we find a higher curvature of consumption, $\sigma = 7.33$, than in the benchmark (where it is equal to 4.07). Furthermore, the adjustment cost parameter for capital investment is estimated to be zero (compared to 1.06 in the benchmark). Hence, one concern might be that our additional investment frictions are only significant because they take over the job that capital adjustment costs play in a standard model. One might also worry that the frictions would become insignificant once we force σ to lie within a more realistic range. In order to address these issues, we conduct the following robustness check.

We re-estimate Specification 3 subject to the following constraints: $\sigma \leq 4.07$ and $S_k'' \geq 1.06$. That is, we impose that σ cannot exceed its benchmark value and S_k'' has to be at least as large as in the benchmark specification.[35]

The estimated coefficients are reported in Table 2.A.3. Reassuringly, the parameters that determine the transmission of tax shocks to the friction are still positive and highly significant. In particular, we find $\xi_k = 2.52$ and $\xi_d = 2.66$. Compared to Specification 3, the capital friction is a bit lower, whereas the durables friction increases substantially.

In accordance with these findings, Figure 2.10 illustrates that our constrained model is better able to match the large empirical tax multipliers for durables purchases and investment than the benchmark model without additional frictions. This fact is also reflected in the value of the weighted distance between the theoretical and empirical impulse responses. For our constrained Specification 3, we find $\mathcal{D} = 52.31$, which is much lower than its counterpart from the benchmark (60.02 in Case 1 of Specification 1).

Therefore, we conclude that our results are robust to parameter constraints. Most importantly, our investment frictions remain highly significant and improve the fit of the model even if we limit our coefficients from Specification 3 to lie within the range of our benchmark specification.

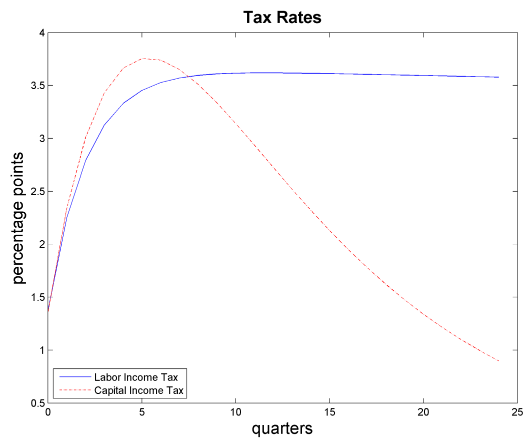
[35] We also estimated the model with both constraints separately. Due to space constraints the tables and figures are not reported here. They are available from the authors upon request. We find that the constraint on σ only affects the durables friction, whereas the constraint on S_k'' lowers the capital friction and increases the durables friction.

Table 2.A.3: Coefficient estimates for Specification 3 with constraints

Parameter	**Explanation**	**Value**	**Standard Error**
σ	Consumption curvature	4.07***	(0.46)
Ψ	Hours curvature	0.50	(0.48)
γ	Weight of hours	8905^c	
π	Habit parameter	0.85***	(0.02)
ϕ	Composite consumption	0.99^c	
ν	Final good production function	1.22^c	
a	Capital utilization parameter	0.06*	(0.03)
b	Capital utilization parameter	0.05^c	
S''_k	Capital adjustment costs	1.06***	(0.15)
S''_d	Durables adjustment costs	0.48***	(0.08)
$\rho_{k,1}$	AR(2) for capital taxes	1.70***	(0.12)
$\rho_{k,2}$	AR(2) for capital taxes	-0.72***	(0.11)
$\rho_{n,1}$	AR(2) for labor taxes	1.61***	(0.08)
$\rho_{n,2}$	AR(2) for labor taxes	-0.61***	(0.08)
$\rho_{fk,1}$	AR(2) for capital friction	0.31***	(0.10)
$\rho_{fk,2}$	AR(2) for capital friction	0.00	(0.08)
$\rho_{fd,1}$	AR(2) for durables friction	0.10	(0.10)
$\rho_{fd,2}$	AR(2) for durables friction	0.00	(0.11)
ξ_k	Initial response of capital friction	2.52***	(0.33)
ξ_d	Initial response of durables friction	2.66***	(0.31)
f_k	Steady state capital friction	0.016^c	
f_d	Steady state durables friction	0.06^c	

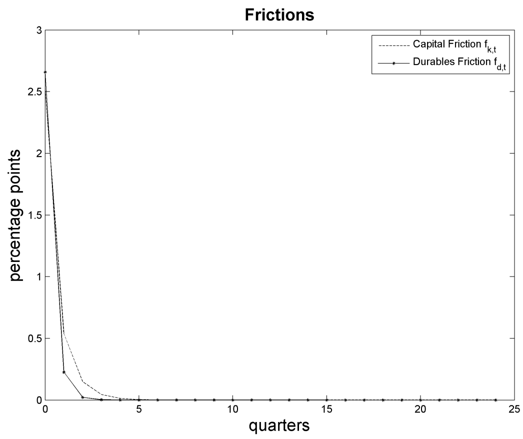
Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. c marks parameters that are not estimated because they are calibrated in steady state. n marks parameters that hit a natural bound. Constraints are $\sigma \leq 4.07$ and $S''_k \geq 1.06$.

Figure 2.A.5: Taxes in Specification 3 with constraints



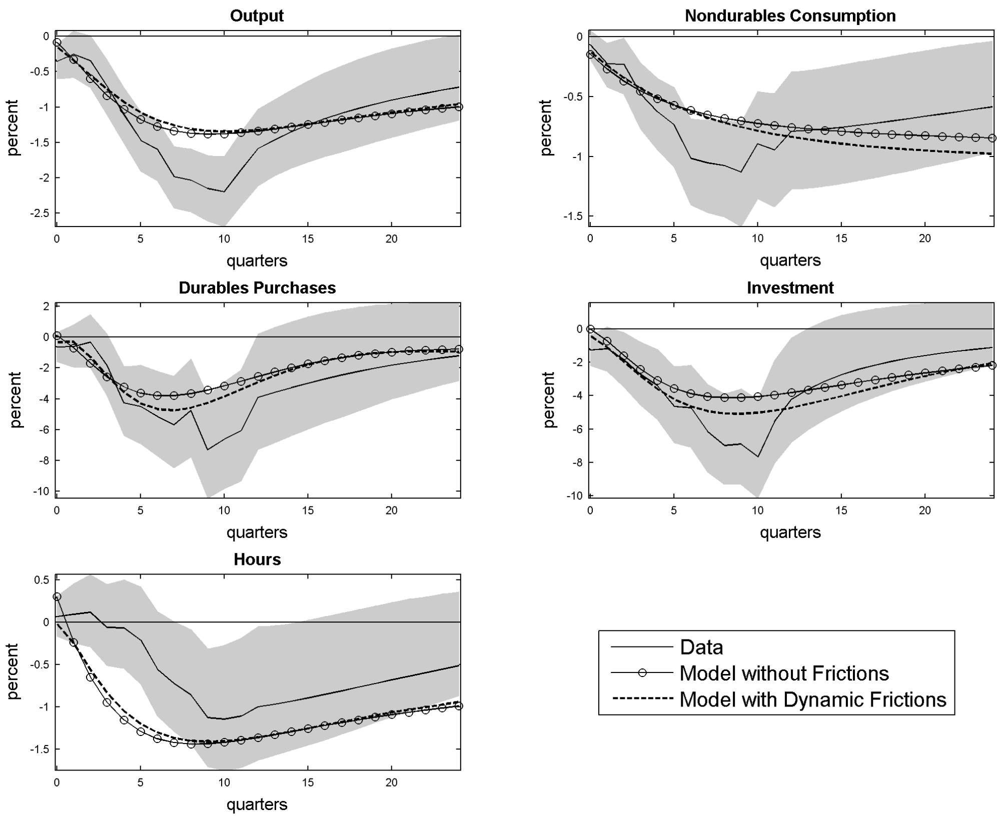
Notes: Estimated dynamics of capital and labor income tax rates in the model with dynamic investment frictions and constraints $\sigma \leq 4.07$ and $S''_k \geq 1.06$.

Figure 2.A.6: Friction dynamics in Specification 3 with constraints



Notes: Estimated dynamics of capital and durables frictions after a shock to capital and labor income taxes. Constraints are $\sigma \leq 4.07$ and $S_k'' \geq 1.06$.

Figure 2.A.7: Impulse responses for Specification 3 with constraints



Notes: Model impulse responses to a shock in capital and labor income taxes in the model with and without dynamic investment frictions. Constraints are $\sigma \leq 4.07$ and $S_k'' \geq 1.06$ in the model with frictions. The solid line represents empirical impulse responses, with the shaded areas corresponding to 68 percent confidence intervals.

3 The Effect of Exchange Rate Fluctuations on Tourism in Switzerland: Evidence from a Panel Error Correction Model

3.1 Introduction

The tourism sector in Switzerland has faced many challenges in the past few years. The economic downturn due to the Great Recession has reduced the willingness to travel, and the strong appreciation of the Swiss franc has made holidays in Switzerland very expensive. The main reason behind the strengthening of the Swiss franc was its safe haven property, which has played an important role during the recent European debt crisis. In order to alleviate the pressure arising from the overvaluation of the Swiss franc, the Swiss National Bank introduced a minimum exchange rate against the euro in September 2011. In January 2015, it decided to discontinue this policy. Both of these interventions fueled the debate about the impact of exchange rate fluctuations on the export industry, and in particular on the tourism sector. Whereas the effect of exchange rates on exports has been widely investigated in the literature, there is only a limited amount of research about the consequences for tourism. The present paper fills this gap by estimating exchange rate elasticities for tourism in Switzerland.

I find that a real (nominal) appreciation of the Swiss franc by one percent leads to a decrease in tourist arrivals by 1.03 (0.60) percent, in overnight stays by 0.49 (0.47) percent, in bed and room occupancy rates by 0.82 (0.92) and 0.84 (0.85) percent respectively, and in revenues per available room by 1.54 (0.87) percent in the long run. My elasticities for overnight stays are at the lower bound of corresponding estimates from previous studies.[1] This is most certainly due to the fact that my elasticities are calculated for an entire exchange rate basket, whereas existing estimates refer to bilateral exchange rates only.

The approach that I develop for the estimation of exchange rate elasticities in tourism is therefore an additional contribution of this paper. Specifically, I rely on within-country variation and effective (as opposed to bilateral) exchange rates. While this method has

[1] Estimates for bilateral exchange rate elasticities of overnight stays in Switzerland are derived by Abrahamsen and Simmons-Süer (2011). They range from 0.45 to 1.83 for nominal exchange rates and from 0.52 to 2.32 for real exchange rates.

been used in the literature to study the effect of exchange rates on different industries (see e.g. Campa and Goldberg 1995, Kaiser and Siegenthaler 2014, and Nucci and Pozzolo 2001), I am the first to apply it to the tourism sector. By doing so, I estimate the effect of fluctuations in the entire exchange rate basket on tourism variables. In contrast to bilateral estimates, this takes into account the possibility of different tourist groups compensating for changes in each other's behavior. Thus, my exchange rate elasticities are suitable to analyze the actual situation of the tourism sector as a whole, whereas bilateral estimates focus on specific tourist groups. In that sense, my method is complementary to existing estimation strategies.

An advantage of using effective exchange rates is that it enables me to estimate exchange rate elasticities for aggregate variables that are not directly attributable to tourists from a specific country of origin. In particular, I additionally assess the effect of exchange rate fluctuations on bed and room occupancy rates as well as on revenues per available room. In contrast, the bilateral method used in previous studies is only able to provide estimates for arrivals and overnight stays and thus misses an important part of the story. For the tourism sector as a whole, not only the absolute number of tourists is relevant, but also how it relates to the supply of beds and to prices paid per room.

My analysis for Switzerland is based on quarterly panel data, covering all 26 cantons and a time span from 2005 to 2013. I document that there is substantial variation in the composition of tourists across cantons. Some regions traditionally attract more visitors from the Euro Area, whereas others are more popular with tourists from overseas or China. I interpret the relative shares of tourists' countries of origin as a measure for the exposure of a canton's tourism sector to the corresponding bilateral exchange rates. This allows me to construct canton-specific exchange rate baskets. I define the effective exchange rate of a canton as the weighted average of bilateral exchange rates, using past tourist shares as weights.

Cointegration tests show that there is a long-run relationship between tourism variables, effective exchange rates, and real effective GDP in tourists' countries of origin. Hence, I am able to estimate exchange rate elasticities in a panel error correction model. The main advantage of this approach is that it provides long-run and short-run elasticities as well as an estimate of the adjustment speed, which is an indicator for how fast the system returns to its equilibrium after a deviation. My method allows for canton-specific short-run dynamics and adjustment coefficients. The long-run exchange rate elasticities, on the other hand, are assumed to be the same for all cantons.

In my baseline estimation, I control for canton fixed effects and a linear time trend. I estimate the model separately for all my tourism measures, i.e. arrivals, overnight stays, bed and room occupancy rates, and revenues per available room. By doing so, I obtain five different sets of coefficients. For each dependent variable, I find significantly positive long-run exchange rate elasticities. The adjustment speed ranges from 30 to 56 percent. My results are robust to alternative specifications, weighting procedures, and different measures for my explanatory variables.

Ideally, one would also want to control for time fixed effects. However, I show that the non-stationarity in effective exchange rates is driven by a large common component for all cantons. This implies that identification becomes problematic once I include time fixed effects. Therefore, I focus on my baseline specification without time fixed effects. The super-consistency property of cointegration parameters ensures that these estimates are not subject to an omitted variable bias. In order to make sure that this asymptotic result also holds in my finite sample, I furthermore conduct an exercise to determine the importance of potential omitted variables that would have been captured by time fixed effects. Reassuringly, I do not find any evidence for an omitted variable bias. Therefore, I conclude that my baseline results are reliable and unbiased even without controlling for time fixed effects.

Related Literature

My paper is related to the literature on tourism demand. An extensive review of recent research on the subject is provided by Song and Li (2008). Within this field, my paper specifically contributes to the strand of literature using error correction models. Lim and McAleer (2001), for example, use this class of models in order to estimate long-run tourism demand for Australia. The same approach is taken by Kulendran and Wilson (2000), who analyze factors influencing long-run demand for business travel to Australia. Bonham, Gangnes, and Zhou (2009) estimate a vector error correction model for tourism in Hawaii, taking into account supply as well as demand effects. In a more technical study, Kulendran and Witt (2003) show that error correction models perform better in terms of forecasting accuracy than alternative time series models for medium- and long-run tourism forecasts. A general description of the application of error correction models in tourism demand modeling is provided by Song and Witt (2000). My empirical strategy differs from these studies mainly because it also takes into account within-country variation, on top of the time dimension. Papers using panel data are less widespread. One example is Falk (2013a), who estimates exchange rate elasticities for Swiss tourists in Austrian ski resorts using a panel error correction model.

Furthermore, there is a growing number of studies that analyze the effect of exchange rates on tourism in Switzerland. A recent paper in that field by Falk (2013b) estimates short-run exchange rate elasticities for winter tourism in 60 communities in Switzerland. He finds that during the winter season, Alpine tourism is more sensitive to exchange rate movements than tourism in lake and city destinations. In contrast to Falk (2013b), I use a much longer time series covering all seasons of the year, which allows me to estimate long-run as well as short-run exchange rate elasticities.[2] A further difference between his approach and the one used in my paper is that Falk (2013b) only considers fluctuations in the bilateral exchange rate between the euro and the Swiss franc in order to explain changes in overall tourist arrivals and overnight stays, whereas I use exchange rate baskets reflecting the varying exposure to different bilateral exchange rates in every canton. Furthermore, while Falk (2013b) focuses on the most important communities in Switzerland, I provide elasticity estimates on an aggregate level. In that sense, my paper is more closely related to the KOF study by Abrahamsen and Simmons-Süer (2011). For each country of origin, they estimate an error correction model for overnight stays of tourists in Switzerland. Their identification relies on changes over time, whereas I additionally exploit variation across cantons in Switzerland. In a more recent paper, Abrahamsen et al. (2015) compare bilateral exchange rate elasticities in Switzerland across different hotel categories. Based on their estimates, they cannot reject the hypothesis of identical elasticities across all categories. A more general analysis of tourism demand in Switzerland is conducted by Ferro-Luzzi and Flückiger (2003). In contrast to my paper, they do not specifically focus on exchange rates.

The remainder of this paper is structured as follows. Section 3.2 describes the data and the construction of the explanatory variables. Section 3.3 performs stationarity and cointegration tests and develops the empirical strategy. Estimation results as well as robustness checks are reported in Section 3.4 and are discussed in Section 3.5. Section 3.6 concludes.

3.2 Data

This section provides an overview of the data used in my empirical analysis. I work with quarterly panel data for all 26 cantons of Switzerland, covering the time span from 2005 to 2013.[3] Subscript i denotes cantons, and t is the time subscript.

The dependent variables in my estimation are measures for tourism activity in Switzerland. My explanatory variables, on the other hand, are weighted averages of bilateral exchange rates and country-specific GDP. Data sources and definitions as well as the construction of the dependent variables are described in the following.

[2] Falk (2013b) bases his estimates on four data points per community only.

[3] The time period is constrained by the availability of data on explanatory variables. Specifically, GDP for India is only available until the end of the year 2013. Tourism variables would actually be available until 2015.

3.2.1 Dependent Variables

The data source for my tourism variables is the HESTA dataset, which is based on a monthly, comprehensive survey conducted by the Bundesamt für Statistik (2015). Participation is mandatory for all establishments providing accommodation in the Swiss tourism sector, namely hotels, motels, hostels, guest houses, health resorts, holiday homes, and campgrounds.[4] My dependent variables are:

- *Arrivals:* Number of tourists who spend at least one night in an accommodation establishment of the Swiss tourism sector.
- *Overnight Stays:* Number of nights that tourists spend in an accommodation establishment of the Swiss tourism sector.
- *Bed Occupancy Rate:* Overnight stays divided by bed capacity during a specific time period, measured in percent. Bed capacity is defined as the number of beds multiplied by the number of days during the time period considered.
- *Room Occupancy Rate:* Number of occupied rooms and nights divided by room capacity during a specific time period, measured in percent. Room capacity is defined as the number of rooms multiplied by the number of days during the time period considered.
- *Revenues per Available Room:* Total income of all accommodation establishments in the Swiss tourism sector divided by room capacity during a specific time period.[5]

Tourism variables are subject to high seasonality. Before estimating the model, I therefore seasonally adjust the data following the procedure given in Baum (2006). In a first step, I regress tourism variables on quarter dummies. The residuals of this regression can be interpreted as the deseasonalized component of the time series. The seasonally adjusted series is constructed by adding the (pre-adjustment) mean to these residuals. I apply this methodology to every canton separately, allowing for different seasonality patterns across cantons.[6]

[4] The survey has a very high response rate of more than 95 percent.

[5] Data on revenues per available room were kindly provided by the Swiss Hotel Association 'hotelleriesuisse' and are only available after 2005. They are based on the same survey as the HESTA data. By taking an average over all different types of accommodation, this measure is rather theoretical and does not account for heterogeneity in room quality.

[6] In the tourism literature, it is common to work with seasonally adjusted data. In many cases, only deseasonalized data are available in the first place. From an econometric point of view, seasonal adjustment reduces the degrees of freedom of the estimation, which should be taken into account when computing standard errors. I do so by reporting adjusted standard errors.

3.2.2 Explanatory Variables

My explanatory variables are:

- *Real Effective Exchange Rate:* Weighted average of bilateral real exchange rates.
- *Nominal Effective Exchange Rate:* Weighted average of bilateral nominal exchange rates.
- *Real Effective GDP:* Weighted average of GDP in the tourists' countries of origin.

Data sources are given in Table 3.A.1 in the Appendix. The methodology for the construction of these variables as well as the weights used in their calculation are discussed in the following.

The concept of effective exchange rates is widely used in the international trade literature. It is based on the fact that every country has more than one trading partner. Therefore, bilateral exchange rates alone do not reflect the conditions that exporters or importers in a certain country face. Addressing this issue, effective exchange rates take into account the composition of a country's trade flows. They are defined as a weighted average of bilateral exchange rates of a country and its trading partners. The more dependent a country is on a certain trading partner, the higher is the latter's weight in the index.

Several organizations, such as the Bank for International Settlements (BIS), the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), and major central banks, provide data on effective exchange rates for different countries and currencies.[7] However, most existing measures of effective exchange rates abstract from tourism services (see Klau and Fung 2006). To my knowledge, the IMF is the only organization that does take into account tourism, but only for "[...] countries that are heavily dependent on trade in tourism services" (Bayoumi, Lee, and Jayanthi 2005, page 9). Therefore, the weights used in the derivation of effective exchange rates are not representative for the tourism sector, but instead focus entirely on trade flows. I thus need to construct a measure for effective exchange rates that reflects the composition of tourists' countries of origin. For this purpose, I define the tourism-specific effective exchange rate for canton i at time t as the weighted average of bilateral exchange rates between the Swiss franc and all countries of origin k:

$$EER_{i,t} = \sum_{j=1}^{k} w_{i,j,t} ER_{j,t} \tag{3.1}$$

[7] See Chinn (2006) for a detailed overview and discussion of different weighting schemes.

where $EER_{i,t}$ stands for the effective exchange rate faced by canton i at time t, and $ER_{j,t}$ denotes the bilateral exchange rate between the Swiss franc and the currency of country j at time t. $w_{i,j,t}$ is the weight of country j in canton i at time t. It can be interpreted as the exposure of the tourism sector in canton i to tourists from country of origin j at a given point in time. k is the total number of countries of origin.[8]

Analogously, real effective GDP in canton i at time t is defined as the weighted average of real GDP in tourists' countries of origin j:

$$REGDP_{i,t} = \sum_{j=1}^{k} w_{i,j,t} RGDP_{j,t}^{norm} \tag{3.2}$$

where $REGDP$ is real effective GDP of tourists in canton i at time t, and $RGDP_{j,t}^{norm}$ denotes (normalized) real GDP of tourists from country of origin j. $w_{i,j,t}$ is identical to the weight used in the construction of effective exchange rates.

Weights

I define the weight of country j in canton i at time t as the lagged share of overnight stays by tourists from country j in canton i over four quarters:

$$w_{i,j,t} = \frac{\sum_{m=4}^{7} overnight\ stays_{i,j,t-m}}{\sum_{m=4}^{7} \sum_{n=1}^{k} overnight\ stays_{i,n,t-m}} \tag{3.3}$$

where k again denotes the total number of different tourists' countries of origin. In order to smooth out seasonality effects, I calculate the share over four quarters from $t-7$ to $t-4$.[9] The lags reduce concerns about endogeneity.[10]

In a next step, I need to choose the number of countries of origin to include in the derivation of weights. Switzerland is visited by many different tourist groups. However, many countries of origin do not play an important role for Swiss tourism. I therefore drop all countries with a share that does not exceed three percent in any canton on average over the time span from 2006 to 2014, from the last quarter in 2013 to the third quarter in 2014, or over all quarters in the year 2006. This results in a sample of eight countries of origin: Switzerland, the Euro Area, the United Kingdom (UK), the United States (US), India, China, Japan, and Russia.[11]

[8] The country of origin of a tourist is defined as his country of permanent residence and hence is not necessarily identical to his nationality.

[9] For the weights in the year 2005, I use the shares from 2003 because data for the year 2004 are missing.

[10] A similar weighting procedure is used by Ferro-Luzzi and Flückiger (2003) in order to measure the aggregate tourism demand for Switzerland. However, they use contemporaneous instead of lagged shares.

[11] In a robustness check, I increase the cutoff to five percent, in which case Japan and Russia drop out.

Table 3.1: Summary statistics for weights of each country of origin

Country of Origin		Mean	Std. Dev.	Minimum	Maximum
Switzerland	overall	56.30	15.82	20.81	92.41
	between		15.74	26.85	86.52
	within		4.78	39.74	75.04
Euro Area	overall	31.25	9.24	6.33	53.46
	between		8.86	11.39	44.55
	within		3.77	17.95	45.19
United States	overall	4.06	3.66	0.05	16.56
	between		3.43	0.35	12.09
	within		1.45	-1.65	14.36
United Kingdom	overall	4.25	3.41	0.06	16.04
	between		3.23	0.53	12.86
	within		1.23	-0.66	10.72
China	overall	1.33	1.98	0.00	15.35
	between		1.36	0.05	4.33
	within		1.44	-2.72	13.61
Russia	overall	0.90	0.97	0.00	6.38
	between		0.85	0.00	4.08
	within		0.47	-0.73	3.57
India	overall	1.05	2.78	0.00	34.47
	between		1.86	0.03	9.66
	within		2.08	-8.58	25.87
Japan	overall	0.85	1.20	0.00	8.92
	between		0.96	0.08	3.52
	within		0.74	-1.86	6.53

These countries are accountable for nearly 90 percent of all overnight stays in Switzerland between 2006 and 2014. Their shares in aggregate tourism in Switzerland are presented in Figure 3.1.[12] Domestic tourism accounts for around 50 percent of all overnight stays. Tourists from the Euro Area are responsible for 30 to 40 percent of tourists visiting Switzerland, whereas the other six countries' shares range from 3 to 9 percent. Figure 3.2 illustrates the variation in the importance of different countries of origin across cantons based on the comparison of the shares in the cantons of Zürich and Appenzell Innerrhoden. The latter is almost entirely dependent on domestic tourists whereas the canton of Zürich is exposed to a wide variety of tourist groups. Between 30 and 40 percent of its tourists come from the Euro Area, around 10 percent from the US, and around 8 percent from the UK. Detailed descriptive statistics of the shares are reported in Table 3.1. The

[12]In the figure, shares of all eight countries sum to 100 percent. The reason is that I choose to display the share data used in the derivation of the weights. As the weights serve as a basis for the calculation of weighted averages, they have to sum to 100 percent.

high standard deviations between cantons confirm that there is substantial variation in the exposure to different countries of origin across cantons.

Figure 3.1: Shares in total overnight stays by country of origin

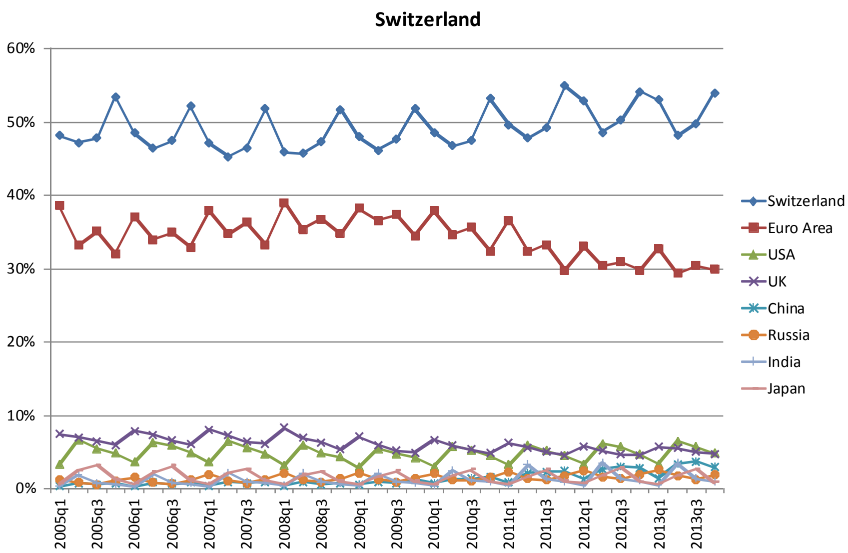
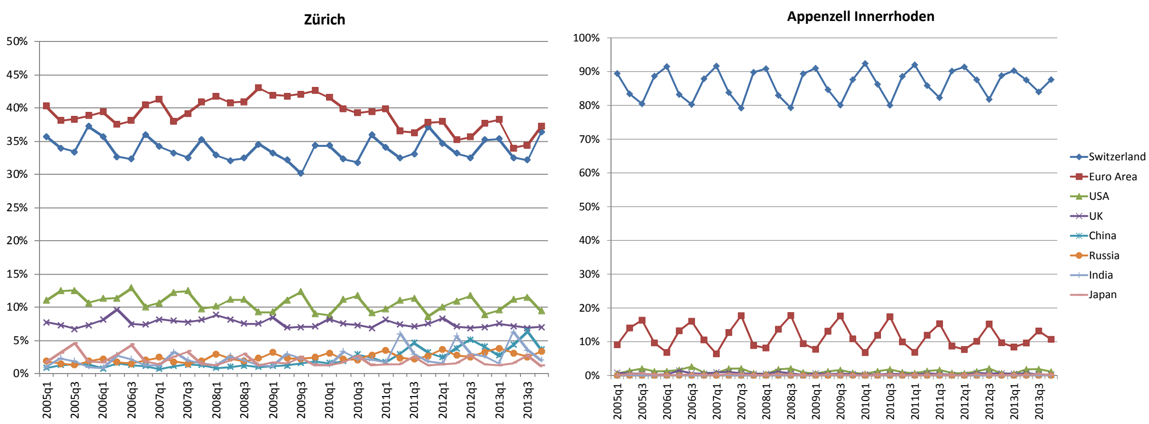


Figure 3.2: Shares in total overnight stays by country of origin



Exchange Rates

All bilateral exchange rates are defined as $CURRENCY_j/CHF$. An exchange rate of $1.20\, EUR/CHF$ therefore means that one euro can buy 1.20 Swiss francs. Hence, an increase in the exchange rate corresponds to a depreciation of the Swiss franc. An appreciation of the Swiss franc, on the other hand, is reflected by a decrease in the exchange rate.

I normalize bilateral nominal exchange rates to 100 in the first quarter of 1999 in order to make them comparable across different countries. Specifically, I apply the following formula:

$$NER_{CH,j,t} = \frac{NER_{CH,j,t}}{NER_{CH,j,0}} \cdot 100 \tag{3.4}$$

where $NER_{CH,j,0}$ is the nominal exchange rate between the Swiss franc and the currency of country j in the base period, that is in the first quarter of 1999. Consistent with the normalization of nominal exchange rates, real exchange rates are calculated following Maciejewski (1983):

$$RER_{CH,j,t} = \frac{NER_{CH,j,t}}{NER_{CH,j,0}} \cdot \frac{CPI_{j,t}/CPI_{j,0}}{CPI_{CH,t}/CPI_{CH,0}} \cdot 100 \tag{3.5}$$

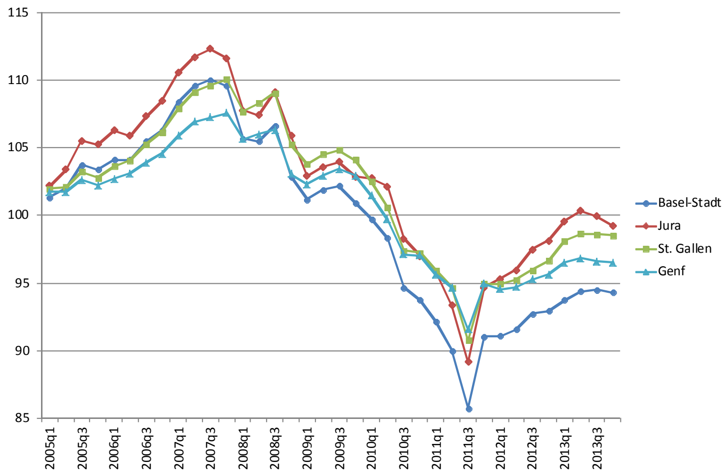
where $RER_{CH,j,t}$ and $NER_{CH,j,t}$ denote real and nominal exchange rates between the currency of country j and the Swiss franc at time t. $CPI_{j,t}$ is the consumer price index of country j. Everything on the right hand side of the equation is measured relative to the base period $t = 0$, which is again the first quarter of 1999.

For Switzerland (i.e. $j = CH$), the case is more complicated. In principle, Swiss tourists do not face an exchange rate when traveling within Switzerland. However, to the extent that they consider taking trips abroad, their decisions are still affected by the strength of the Swiss franc with respect to other currencies. Therefore, I define the exchange rate for Swiss tourists as a weighted average of the exchange rates between the Swiss franc and the currencies of the main Swiss tourist destinations.[13] In a robustness check, I also consider a definition in which the exchange rate for Swiss residents is held constant at a level of 100 for all points in time.

Measures of the real and nominal effective exchange rate for the cantons Basel-Stadt, Jura, St. Gallen, and Genf are presented in Figures 3.3 and 3.4 respectively. The comparison of the four time series confirms that there is indeed variation in terms of the exposure to exchange rate fluctuations across cantons. However, there is also a large common com-

[13] The Bundesamt für Statistik (2009) documents that in 2003, 51 percent of Swiss tourists traveled within Switzerland, and 42 percent went to the Euro Area. The shares of other countries are negligible. The exchange rate for the Swiss franc with itself is set to 100 for all points in time. The weights are fixed at their level of 2003.

Figure 3.3: Real effective exchange rates for different cantons



ponent in the effective exchange rates of all cantons, which results in a strong comovement of the time series.[14]

Real GDP

Data on real GDP are seasonally adjusted. Furthermore, GDP is expressed in terms of the national currency of every country of origin.[15] In order to make the measures comparable across different countries, I therefore need to normalize them. For this purpose, I use data for purchasing power parity (PPP) adjusted GDP per capita from the year 1999 provided by the World Bank (2015b). For this particular year, I normalize PPP-adjusted GDP per capita of the US to 100 and compute real GDP for country j at every point in time accordingly. This implies the following normalization:

$$RGDP_{j,t}^{norm} = \frac{RGDP_{j,t}}{RGDP_{j,0}} \cdot \frac{PPPRGDPpc_{j,0}}{PPPRGDPpc_{US,0}} \cdot 100 \tag{3.6}$$

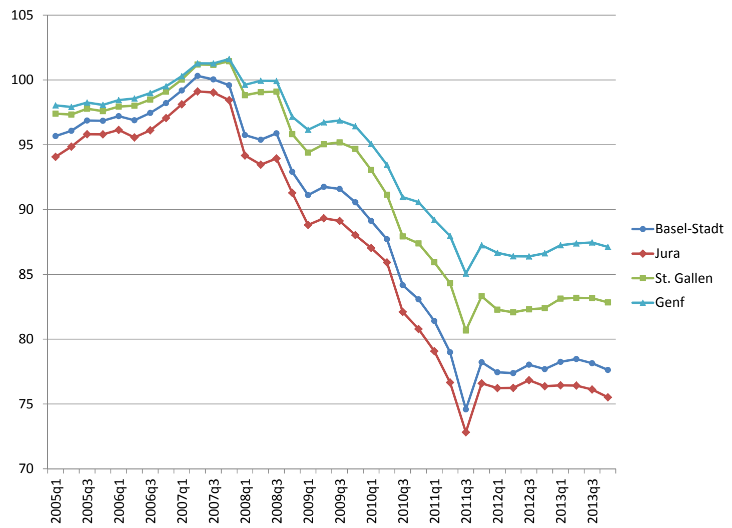
where $PPPRGDPpc_{j,0}$ denotes PPP-adjusted GDP per capita in $t = 0$, that is in the year 1999. $RGDP_{j,t}$ is real GDP of country j at time t expressed in units of national currency. The resulting time series of real effective GDP for the cantons Basel-Stadt, Jura, St. Gallen, and Genf are presented in Figure 3.5.

In order to conduct robustness checks, I apply two alternative normalization methods to the data. In the first case, I use PPP-adjusted aggregate GDP instead of GDP per capita in the formula above. In the second case, I simply normalize the GDP of every

[14] I provide possible explanations for this point in Section 3.5.

[15] GDP for India is not available for the year 2014. This is the reason why my estimation period ends in 2013.

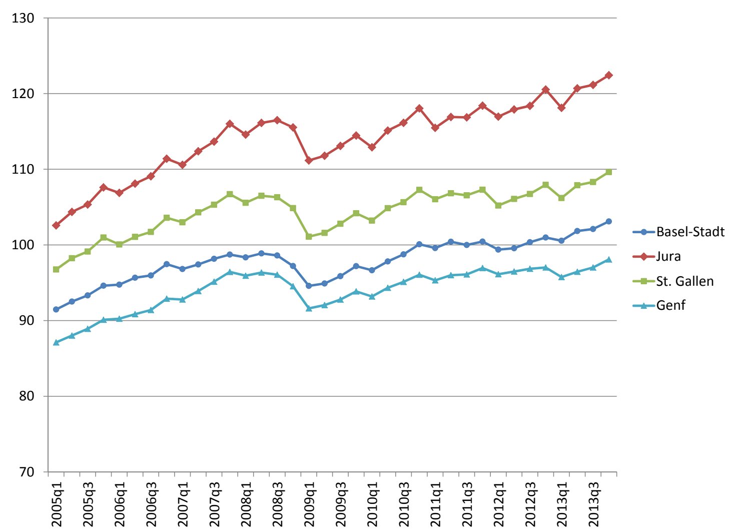
Figure 3.4: Nominal effective exchange rates for different cantons



country to 100 in 1999, without taking into account differences in the levels across countries.

Data derived according to Equations (3.3), (3.4), (3.5), and (3.6) are used in the formula for the effective exchange rate given in Equation (3.1) and for real effective GDP in Equation (3.2). Having defined all dependent and explanatory variables, I now proceed to the estimation of my model.

Figure 3.5: Real effective GDP for different cantons



3.3 Empirical Strategy

Based on the fact that travel decisions are usually made a few quarters in advance, a reasonable starting point for the estimation of the relationship between Swiss tourism and exchange rates is an autoregressive distributed lag (ARDL) dynamic panel model:

$$ln(Y_{i,t}) = \sum_{j=1}^{p} \eta_{ij} ln(Y_{i,t-j}) + \sum_{j=0}^{p} \kappa_{ij} ln(EER_{i,t-j}) + \sum_{j=0}^{p} \delta_{ij} ln(REGDP_{i,t-j}) + \varepsilon_{i,t} \quad (3.7)$$

where Y denotes a tourism measure, such as arrivals, overnight stays, bed and room occupancy rates, or revenues per available room. The current value of the tourism variable is regressed on its own lags as well as on current and lagged values of the effective exchange rate, denoted by EER, and real effective GDP in tourists' countries of origin, denoted by $REGDP$.

Depending on the order of integration of my variables, there are three alternative ways of estimating Equation (3.7). First, if all variables are stationary, then the ARDL model can be estimated in levels. If my variables are non-stationary, on the other hand, then the estimation of the model in levels can produce spurious regression results. In that case, stationarity can be achieved by estimating Equation (3.7) in differences. However, while this solves the spurious regression problem, it also leads to a loss of valuable information on the relationship between the levels of the variables and makes it impossible to estimate long-run exchange rate elasticities. Fortunately, there is a third case. If there is a linear combination of my variables that is stationary, then they are cointegrated. Based on the Granger Representation Theorem by Engle and Granger (1987), the existence of a cointegration relationship ensures that the model has an error correction representation. In that case, Equation (3.7) can be reparametrized into a panel error correction model (PECM). A convenient property of error correction models is that both long-run and short-run coefficients can be estimated.

In order to choose the appropriate econometric model for my estimation, I first determine the order of integration of all my variables and then test them for cointegration.

3.3.1 Unit Root Tests

In order to test whether my variables contain unit roots, I use the augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1979). It fits the following model:

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta t + \sum_{j=1}^{k} \zeta_j \Delta y_{t-j} + \varepsilon_t \quad (3.8)$$

Table 3.2: Unit root tests for dependent variables

Canton	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Z_t	p	Z_t	p	Z_t	p	Z_t	p	Z_t	p
Zürich	-2.41	(0.38)	-2.61	(0.28)	-2.85	(0.18)	-2.78	(0.20)	-4.07	(0.01)
Bern	-2.36	(0.40)	-2.79	(0.20)	-3.02	(0.13)	-2.81	(0.19)	-2.49	(0.33)
Luzern	-3.18	(0.09)	-3.72	(0.02)	-2.31	(0.43)	-2.66	(0.25)	-1.53	(0.82)
Uri	-2.09	(0.55)	-2.13	(0.53)	-2.00	(0.60)	-2.12	(0.53)	-3.17	(0.09)
Schwyz	-2.32	(0.43)	-2.07	(0.56)	-2.77	(0.21)	-2.25	(0.46)	-2.85	(0.18)
Obwalden	-3.13	(0.10)	-3.88	(0.01)	-2.61	(0.28)	-2.31	(0.43)	-1.62	(0.78)
Nidwalden	-1.41	(0.86)	-1.69	(0.76)	-0.81	(0.97)	-1.08	(0.93)	-1.08	(0.93)
Glarus	-2.25	(0.46)	-2.13	(0.53)	-1.81	(0.70)	-2.53	(0.32)	-2.25	(0.46)
Zug	-2.97	(0.14)	-2.54	(0.31)	-2.75	(0.21)	-2.44	(0.36)	-2.76	(0.21)
Freiburg	-1.83	(0.69)	-1.54	(0.82)	-1.77	(0.72)	-1.56	(0.81)	-2.54	(0.31)
Solothurn	-2.31	(0.43)	-2.34	(0.41)	-2.28	(0.45)	-2.31	(0.43)	-2.09	(0.55)
Basel-Stadt	-1.97	(0.62)	-3.80	(0.02)	-3.72	(0.02)	-3.80	(0.02)	-3.35	(0.06)
Basel-Land	-1.89	(0.66)	-2.98	(0.14)	-2.44	(0.36)	-2.23	(0.47)	-2.19	(0.50)
Schaffhausen	-2.48	(0.34)	-2.50	(0.33)	-1.96	(0.62)	-1.65	(0.77)	-1.44	(0.85)
Appenzell-AR	-1.16	(0.92)	-1.48	(0.83)	-2.58	(0.29)	-2.25	(0.46)	-2.20	(0.49)
Appenzell-IR	-3.27	(0.07)	-2.25	(0.46)	-2.02	(0.59)	-1.75	(0.73)	-1.76	(0.72)
St. Gallen	-1.75	(0.73)	-3.13	(0.10)	-3.53	(0.04)	-3.45	(0.04)	-2.78	(0.20)
Graubünden	-2.25	(0.46)	-2.62	(0.27)	-2.98	(0.14)	-3.30	(0.07)	-2.98	(0.14)
Aargau	-2.56	(0.30)	-3.48	(0.04)	-3.40	(0.05)	-2.98	(0.14)	-3.33	(0.06)
Thurgau	-2.46	(0.35)	-2.91	(0.16)	-2.83	(0.19)	-2.82	(0.19)	-3.35	(0.06)
Tessin	-2.67	(0.25)	-2.29	(0.44)	-2.37	(0.40)	-2.30	(0.43)	-3.41	(0.05)
Waadt	-3.00	(0.13)	-2.81	(0.19)	-2.66	(0.25)	-2.57	(0.30)	-3.29	(0.07)
Wallis	-3.18	(0.09)	-2.57	(0.30)	-2.71	(0.23)	-3.13	(0.10)	-3.75	(0.02)
Neuenburg	-2.23	(0.48)	-2.27	(0.45)	-2.66	(0.25)	-2.75	(0.22)	-3.66	(0.02)
Jura	-3.75	(0.02)	-3.15	(0.09)	-2.47	(0.34)	-3.13	(0.10)	-3.27	(0.07)
Genf	-2.06	(0.57)	-2.37	(0.40)	-3.49	(0.04)	-3.95	(0.01)	-3.11	(0.10)

Notes: Test statistics from the augmented Dickey-Fuller unit root test including 3 lags and a linear time trend. p-values in parentheses. The null hypothesis that the variable contains a unit root is rejected if the test statistic is lower than the critical values: -4.316 (1%), -3.572 (5%), and -3.223 (10%) for the first four variables and -4.325 (1%), -3.588 (5%), and -3.233 (10%) for revenues.

Under the null hypothesis, y follows a unit root process, and thus, $H_0 : \beta = 0$. Under the alternative, the process is stationary, and therefore, $H_a : \beta < 0$. The test statistic is given by:

$$Z_t = \frac{\hat{\beta}}{\hat{\sigma}_\beta}$$

with $\hat{\sigma}_\beta$ being the standard error of $\hat{\beta}$.

I conduct this test separately for every canton in my sample. In order to take care of possible serial correlation, $k = 3$ lags of the dependent variable are included. Furthermore, I allow for a linear time trend. Table 3.2 presents the resulting values of the test statistics for my tourism variables, together with approximate p-values developed by MacKinnon (1994). At a confidence level of one percent, I find that all variables exhibit a unit root in

Table 3.3: Unit root tests for explanatory variables

Canton	**Real Exchange Rate**		**Nominal Exchange Rate**		**Real GDP**	
	Z_t	p	Z_t	p	Z_t	p
Zürich	-2.30	(0.43)	-2.29	(0.44)	-2.04	(0.58)
Bern	-2.33	(0.42)	-2.36	(0.40)	-1.82	(0.69)
Luzern	-2.31	(0.43)	-2.28	(0.44)	-1.76	(0.72)
Uri	-2.30	(0.44)	-2.35	(0.41)	-1.97	(0.62)
Schwyz	-2.19	(0.49)	-2.27	(0.45)	-2.07	(0.56)
Obwalden	-2.47	(0.34)	-2.38	(0.39)	-2.29	(0.44)
Nidwalden	-2.19	(0.50)	-2.30	(0.44)	-1.50	(0.83)
Glarus	-2.22	(0.48)	-2.23	(0.47)	-1.83	(0.69)
Zug	-2.36	(0.40)	-2.30	(0.43)	-2.09	(0.55)
Freiburg	-2.21	(0.49)	-2.23	(0.47)	-1.85	(0.68)
Solothurn	-2.25	(0.46)	-2.32	(0.42)	-1.98	(0.61)
Basel-Stadt	-2.22	(0.48)	-2.31	(0.43)	-2.08	(0.56)
Basel-Land	-2.32	(0.42)	-2.26	(0.46)	-2.20	(0.49)
Schaffhausen	-2.22	(0.48)	-2.22	(0.48)	-1.41	(0.86)
Appenzell-AR	-2.22	(0.48)	-2.28	(0.45)	-1.90	(0.66)
Appenzell-IR	-2.24	(0.47)	-2.28	(0.45)	-1.89	(0.66)
St. Gallen	-2.23	(0.47)	-2.29	(0.44)	-1.99	(0.61)
Graubünden	-2.25	(0.46)	-2.26	(0.46)	-1.71	(0.75)
Aargau	-2.36	(0.40)	-2.24	(0.47)	-1.65	(0.77)
Thurgau	-2.25	(0.46)	2.27	(0.45)	-1.95	(0.63)
Tessin	-2.22	(0.48)	-2.26	(0.45)	-1.93	(0.64)
Waadt	-2.19	(0.50)	-2.25	(0.46)	-1.75	(0.73)
Wallis	-2.25	(0.46)	-2.27	(0.45)	-1.45	(0.85)
Neuenburg	-2.19	(0.50)	-2.26	(0.46)	-1.88	(0.66)
Jura	-2.30	(0.44)	-2.35	(0.41)	-2.24	(0.47)
Genf	-2.27	(0.45)	-2.29	(0.44)	-1.99	(0.61)

Notes: Test statistics from the augmented Dickey-Fuller unit root test including 3 lags and a linear time trend. p-values in parentheses. The null hypothesis that the variable contains a unit root is rejected if the test statistic is lower than the critical values: -4.316 (1%), -3.572 (5%), and -3.223 (10%).

all cantons. Once I increase the confidence level to ten percent, arrivals, overnight stays, and the room occupancy rate contain a unit root in 21 cantons and bed occupancy rates in 22 cantons. For revenues per available room, I find evidence against the null in favor of the alternative of stationarity in 10 cantons. Given that Switzerland has a total of 26 cantons, I still do not reject the null of unit roots in the majority of cantons for all variables. I therefore proceed under the assumption that all my dependent variables are integrated of order one. However, the results should be interpreted under the caveat that the assumption of unit roots might not hold perfectly in case of revenues per available rooms.

For my explanatory variables, I report the results of the ADF test in Table 3.3. The size of the test statistics as well as the corresponding large p-values confirm that all variables are integrated of order one in all cantons, independently of the significance level applied.

3.3.2 Cointegration Tests

Given that all my variables are integrated of order one, the next step is to test them for cointegration. For this purpose, I use four panel data cointegration tests developed by Westerlund (2007). All tests are based on the following regression model:

$$\Delta y_{i,t} = \delta_i' d_t + \alpha_i (y_{i,t-1} - \beta_i' x_{i,t-1}) + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \gamma_{ij} \Delta x_{i,t-j} + \varepsilon_{i,t} \tag{3.9}$$

Under the null hypothesis of no cointegration, the adjustment coefficient α_i is equal to zero, i.e. $H_0 : \alpha_i = 0$. If there is cointegration between the variables, the null is rejected in favor of the alternative hypothesis, which is given by $H_a : \alpha_i < 0$. The four tests differ in their assumptions about α_i. Two tests assume that the adjustment coefficient is the same for all panels, i.e. $\alpha_i = \alpha$. In contrast to these so-called group-mean tests, another set of tests allows α_i to differ across panels. In the latter case, the alternative hypothesis postulates that $\alpha_i < 0$ for at least one panel. For this reason, those tests are called panel tests.[16]

The group-mean tests are calculated in a three-step procedure. First, Equation (3.9) is estimated for all panels separately. The resulting residuals, $\hat{\varepsilon}_{i,t}$, and the resulting coefficients, $\hat{\gamma}_{ij}$, are used in a second step to obtain $\hat{u}_{i,t} = \sum_{j=0}^{p_i} \hat{\gamma}_{ij} \Delta x_{i,t-j} + \hat{\varepsilon}_{i,t}$. The long-run variances of $\hat{u}_{i,t}$ and $\Delta y_{i,t}$ are denoted by $\hat{\omega}_{ui}$ and $\hat{\omega}_{yi}$ respectively and are estimated following Newey and West (1994). In a third step, the test statistics are defined as:

$$G_\tau = \frac{1}{N} \sum_{i=1}^{N} \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \tag{3.10}$$

$$G_\alpha = \frac{1}{N} \sum_{i=1}^{N} \frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \tag{3.11}$$

where $\hat{\alpha}_i(1) = \frac{\hat{\omega}_{ui}}{\hat{\omega}_{yi}}$ is the ratio of the long-run variances computed in step 2.

The panel tests are constructed under the assumption that α is identical for all panels. Accordingly, the test statistics are given by:

$$P_\tau = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \tag{3.12}$$

[16] See Persyn and Westerlund (2008) for a more detailed description of the method.

and

$$P_\alpha = T\hat{\alpha} \tag{3.13}$$

In my baseline specification, the test statistics are based on Equation (3.9) with $y_{i,t}$ being one of my tourism variables, such as arrivals, overnight stays, bed and room occupancy rates, and revenues per available room. $x_{i,t}$ contains either the real or the nominal effective exchange rate, as well as real effective GDP. I choose the lag length based on the Akaike information criterion, and I allow for a canton-specific constant in the cointegration relationship.

Table 3.4: Cointegration tests for baseline specification

	Real Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-2.48	(0.01)	-3.42	(0.00)	-2.93	(0.00)	-3.00	(0.00)	-2.74	(0.00)
G_α	-12.79	(0.00)	-17.50	(0.00)	-15.25	(0.00)	-15.90	(0.00)	-11.69	(0.02)
P_τ	-11.28	(0.01)	-14.06	(0.00)	-14.46	(0.00)	-14.02	(0.00)	-11.00	(0.01)
P_α	-11.79	(0.00)	-16.29	(0.00)	-17.10	(0.00)	-17.22	(0.00)	-13.54	(0.00)
	Nominal Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-2.52	(0.00)	-3.57	(0.00)	-3.03	(0.00)	-2.95	(0.00)	-2.65	(0.00)
G_α	-12.21	(0.01)	-17.66	(0.00)	-15.47	(0.00)	-16.07	(0.00)	-12.93	(0.00)
P_τ	-12.03	(0.00)	-14.69	(0.00)	-14.55	(0.00)	-14.37	(0.00)	-11.34	(0.01)
P_α	-13.10	(0.00)	-17.09	(0.00)	-17.07	(0.00)	-17.44	(0.00)	-13.61	(0.00)

Notes: Test statistics from the panel data cointegration tests by Westerlund (2007) including a canton-specific constant. Lag length determined by the Akaike information criterion. p-values in parentheses. Under the null hypothesis, the variables are not cointegrated.

Table 3.4 reports the test statistics given in Equations (3.10)-(3.13) for my baseline specification. The upper panel shows the results for the model with the real effective exchange rate as an explanatory variable, and the lower panel presents the test statistics for the model with the nominal effective exchange rate. In both regressions, I additionally control for real effective GDP. The null hypothesis of no cointegration is clearly rejected in all cases. This result is mostly robust to the inclusion of a panel-specific linear time trend. Table 3.A.2 in the Appendix reports the corresponding test statistics. In that case, one out of the four tests, the group-mean test G_α, fails to reject the null for revenues per available room for both nominal and real effective exchange rates. Given that the unit root tests in Section 3.3.1 are ambiguous for revenues per available room, this result is not surprising. For the model of arrivals and the real exchange rate, the G_α test is also not able to reject the null hypothesis of no cointegration. However, given that the p-value of 0.28 is still rather low and that the other three tests provide strong evidence in favor of the alternative hypothesis, I proceed under the assumption of cointegration for arrivals.

In a next step, I add time fixed effects to Equation (3.9). As shown in Table 3.5, the null hypothesis of no cointegration is strongly rejected for all dependent variables. When I include a canton-specific linear time trend in addition to the time dummies, I still find cointegration for all variables except for revenues per available room, for which the tests are again indecisive (see Table 3.A.3 in the Appendix).

All in all, I conclude that there is a cointegration relationship between my tourism variables, effective exchange rates, and real effective GDP. However, for revenues per available room, some caution is required because the results are ambiguous.

Table 3.5: Cointegration tests for specification with time fixed effects

	Real Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-2.78	(0.00)	-3.03	(0.00)	-3.03	(0.00)	-2.78	(0.00)	-2.95	(0.00)
G_α	-14.59	(0.00)	-15.82	(0.00)	-16.91	(0.00)	-14.91	(0.00)	-13.29	(0.00)
P_τ	-15.01	(0.00)	-13.55	(0.00)	-16.02	(0.00)	-15.22	(0.00)	-12.92	(0.00)
P_α	-14.51	(0.00)	-13.74	(0.00)	-17.91	(0.00)	-16.01	(0.00)	-12.92	(0.00)
	Nominal Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-2.80	(0.00)	-2.93	(0.00)	-2.79	(0.00)	-2.45	(0.01)	-2.97	(0.00)
G_α	-14.22	(0.00)	-14.07	(0.00)	-15.44	(0.00)	-12.66	(0.00)	-11.64	(0.02)
P_τ	-15.24	(0.00)	-13.82	(0.00)	-15.51	(0.00)	-14.06	(0.00)	-13.68	(0.00)
P_α	-14.60	(0.00)	-13.97	(0.00)	-17.36	(0.00)	-14.84	(0.00)	-13.41	(0.00)

Notes: Test statistics from the panel data cointegration tests by Westerlund (2007) including a canton-specific constant and time fixed effects. Lag length determined by the Akaike information criterion. p-values in parentheses. Under the null hypothesis, the variables are not cointegrated.

3.3.3 Panel Error Correction Model

Given that my variables are cointegrated, I estimate the following baseline panel error correction model (PECM):[17]

$$\Delta ln(Y_{i,t}) = \phi_i \left[ln(Y_{i,t-1}) - \beta_1 ln(EER_{i,t-1}) - \beta_2 ln(REGDP_{i,t-1}) - \mu_i - \rho t\right] \quad (3.14)$$
$$+ \sum_{j=1}^{p-1} \tilde{\eta}_{ij} \Delta ln(Y_{i,t-j}) + \sum_{j=0}^{p-1} \tilde{\kappa}_{ij} \Delta ln(EER_{i,t-j}) + \sum_{j=0}^{p-1} \tilde{\delta}_{ij} \Delta ln(REGDP_{i,t-j}) + \gamma_i + \tilde{\varepsilon}_{i,t}$$

where Δ denotes the difference with respect to the previous quarter. The term in the square brackets is the error correction equation, which describes the long-run (cointegration) relationship between the variables. Under the assumption of weak exogeneity, ϕ_i can be interpreted as the speed of adjustment after a deviation from equilibrium.[18] Y is a seasonally adjusted tourism measure, such as arrivals, overnight stays, bed and room occupancy rates, or revenues per available room. $REGDP$ represents the canton-specific basket of seasonally adjusted real GDP in tourists' countries of origin. It controls for demand shocks due to a change in tourists' income. EER is the nominal or real effective exchange rate, depending on the specification. γ_i allows for a linear time trend in the level of the variables. Analogously, ρ permits the cointegration relationship to be stationary around a linear time trend.[19] μ_i is a canton fixed effect. In addition to this baseline specification, I also conduct a robustness check in which I estimate Equation (3.14) with time fixed effects. In that case, the linear time trend in the cointegration relationship, which is assumed to be common to all cantons, becomes redundant.

The coefficients of interest are β_1 and β_2. Due to the log-log specification, β_1 can be directly interpreted as long-run exchange rate elasticity and β_2 as long-run income elasticity of the tourism variable Y. Exchange rates are defined such that an increase corresponds to an appreciation of foreign currencies with respect to the Swiss franc. In that case, Swiss tourism services become cheaper for foreigners, and therefore I expect $\beta_1 > 0$. A higher real GDP in tourists' countries of origin is also expected to increase demand of Swiss tourism services, and I therefore hypothesize that $\beta_2 > 0$. The speed of

[17]The tilde on top of the coefficients does not have a particular meaning. Its only purpose is to emphasize that the parameters and the error term in the PECM model in Equation (3.14) are not identical to their counterparts in the ARDL model in Equation (3.7).

[18]The assumption of weak exogeneity might be violated in my case due to the fact that the weights I use in the construction of effective exchange rates and real effective GDP are time-varying. In a robustness check, I therefore use ex-ante fixed weights from the year 2003. As is documented in Section 3.4.2, the resulting coefficients for the adjustment speed are almost identical in both estimations. This is reassuring and indicates that the weak exogeneity assumption is reasonable.

[19]Including a linear time trend in the long-run relationship is standard in the literature, see e.g. Bonham, Gangnes, and Zhou (2009), Moore (2010), and Falk (2013a).

adjustment parameter, on the other hand, should be significantly negative, i.e. $\phi_i < 0$. Otherwise, the system does not return to its long-run equilibrium after a deviation, which implies that there exists no cointegration relationship.

I estimate Equation (3.14) using the pooled mean group (PMG) estimator developed by Pesaran, Shin, and Smith (1999). Identification is based on the assumption that long-run coefficients are the same for all cantons, whereas short-run coefficients and standard errors are allowed to be canton specific. In doing so, the PMG estimator combines the advantages of a classical dynamic fixed effects model, which pools the data and restricts all coefficients to be identical across panels, and a mean group approach that estimates the regression separately for every canton.

All parameters are estimated using a maximum likelihood procedure.[20] The lag length is chosen based on the Schwarz Bayesian and Akaike information criterion. Given the panel structure of my data, one might want to work with cluster-robust standard errors. However, to the best of my knowledge, clustering has not been justified in the PMG setting.[21]

3.4 Results

In this section, I present the results from my estimation of Equation (3.14). I furthermore provide several robustness checks in which I use different measures for my explanatory variables. Last but not least, I introduce time fixed effects into my baseline specification. In each case, the estimation is conducted separately for real and nominal exchange rates.

3.4.1 Baseline Results

Table 3.6 shows the results from my baseline estimation for real exchange rates. The upper panel of the table reports the long-run coefficients, and the lower panel contains the short-run effects. Every column presents the results for a different dependent variable. My main parameter of interest is the exchange rate elasticity, which is given by the long-run coefficient on the effective exchange rate. It is positive and highly significant for each of my five tourism variables. According to my estimates, a real depreciation of the Swiss franc by one percent increases tourist arrivals by 1.03 percent, overnight stays by 0.49 percent, bed and room occupancy rates by 0.82 and 0.84 percent respectively, and revenues per available room by 1.54 percent. The adjustment coefficients, on the other hand, are all significantly negative and lie between -0.36 and -0.51. Under the assumption

[20] See Blackburne and Frank (2007) for a detailed description of the implementation in Stata.

[21] I thank Jeff Wooldridge for confirming this point.

of weak exogeneity, they can be interpreted as the speed of adjustment back to the long-run equilibrium after a shock. Thus, an adjustment parameter of -0.37 for arrivals means that if the system is out of its long-run equilibrium, 37 percent of the (remaining) deviation is corrected in each quarter. I find a higher adjustment speed for occupancy rates and revenues per available room than for arrivals and overnight stays.

Although my primary focus lies on exchange rate effects, it is worth mentioning that the long-run coefficients on real effective GDP all have the expected positive sign or are insignificant. This is remarkable because the previous literature has found it difficult to obtain reasonable parameter estimates for GDP. Abrahamsen and Simmons-Süer (2011) find that for most countries of origin, the coefficient on the demand variable is either insignificant or has an unexpected sign. Bonham, Gangnes, and Zhou (2009) also seem to have trouble with their coefficient on real GDP as they have to restrict it in order to get economically plausible results. It is reassuring that my estimation method does not share the difficulties encountered by the previous literature.

Even in the short run, almost all of my coefficients on $REGDP$ are significantly positive. In contrast, my short-run coefficients on $REER$ are mostly insignificant, confirming that it may take some time for exchange rate fluctuations to affect tourism. Furthermore, I find a significantly negative autocorrelation for all my dependent variables.

Table 3.7 reports the baseline results for nominal exchange rates. I find highly significant long-run exchange rate elasticities of 0.60 for arrivals, 0.47 for overnight stays, 0.92 and 0.85 for bed and room occupancy rates respectively, and 0.87 for revenues per available room. Thus, my estimates for real and nominal exchange rates are similar in magnitude for overnight stays and occupancy rates. In the case of arrivals and revenues per available room, the coefficients are lower for nominal exchange rates. As to the adjustment coefficient, I find slightly higher estimates in the case of nominal exchange rates for all variables except arrivals. Moreover, the long-run coefficients on $REGDP$ are all positive, which again makes my approach stand out compared to previous studies. The short-run estimates give rise to the same conclusions as in the specification with real exchange rates. I find significantly positive coefficients on $REGDP$ and consistently negative autoregressive parameters. The short-run effect of $NEER$ on tourism is again inconclusive.

The exchange rate elasticities computed based on my approach are at the lower bound of bilateral estimates documented in previous studies.[22] In order to understand this difference, it is important to note that my exchange rate elasticities are calculated with respect to an entire basket of currencies, whereas previous estimates focus on bilateral

[22] The most recent estimates of bilateral exchange rate elasticities for overnight stays in Switzerland are provided by Abrahamsen and Simmons-Süer (2011). They range from 0.45 to 1.83 for nominal exchange rates and from 0.52 to 2.32 for real exchange rates.

Table 3.6: Baseline results for real exchange rates

Dependent Variable (Y):	Arrivals		Nights		Bed OR		Room OR		Revenues	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	1.03***	(0.12)	0.49***	(0.06)	0.82***	(0.09)	0.84***	(0.06)	1.54***	(0.10)
$ln(REGDP)_{t-1}$	-0.14	(0.21)	0.75***	(0.11)	1.37***	(0.13)	0.82***	(0.10)	-0.20	(0.14)
Adjustment coefficient (ϕ)	-0.37***	(0.09)	-0.36***	(0.10)	-0.44***	(0.09)	-0.39***	(0.10)	-0.51***	(0.12)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.32***	(0.06)	-0.39***	(0.08)	-0.38***	(0.08)	-0.35***	(0.08)	-0.31***	(0.10)
$\Delta ln(Y)_{t-2}$	-0.39***	(0.06)	-0.32***	(0.08)	-0.29***	(0.06)	-0.25***	(0.07)	-0.27***	(0.07)
$\Delta ln(Y)_{t-3}$	-0.24***	(0.05)	-0.21***	(0.06)	-0.18***	(0.04)	-0.16***	(0.05)	-0.12**	(0.05)
$\Delta ln(REER)_{t}$	0.10	(0.15)	0.16	(0.15)	0.31**	(0.12)	0.37**	(0.17)	0.57***	(0.18)
$\Delta ln(REER)_{t-1}$	-0.07	(0.15)	-0.02	(0.14)	0.14	(0.11)	0.12	(0.15)	-0.20	(0.20)
$\Delta ln(REER)_{t-2}$	-0.19	(0.16)	-0.11	(0.18)	-0.09	(0.16)	-0.05	(0.19)	-0.55**	(0.25)
$\Delta ln(REER)_{t-3}$	-0.39***	(0.13)	-0.17	(0.17)	-0.32***	(0.11)	-0.31**	(0.16)	-0.78***	(0.18)
$\Delta ln(REGDP)_{t}$	0.38**	(0.17)	0.62***	(0.17)	0.78***	(0.21)	0.66***	(0.18)	0.30	(0.30)
$\Delta ln(REGDP)_{t-1}$	0.68***	(0.19)	0.52***	(0.17)	0.54**	(0.27)	0.62***	(0.22)	1.22***	(0.32)
$\Delta ln(REGDP)_{t-2}$	0.35**	(0.15)	0.55***	(0.18)	0.67**	(0.28)	0.77***	(0.23)	0.97***	(0.30)
$\Delta ln(REGDP)_{t-3}$	0.79***	(0.14)	0.63***	(0.15)	0.87***	(0.23)	0.94***	(0.20)	1.43***	(0.31)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.7: Baseline results for nominal exchange rates

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	0.60***	(0.05)	0.47***	(0.06)	0.92***	(0.06)	0.85***	(0.06)	0.87***	(0.10)
$ln(REGDP)_{t-1}$	0.16	(0.10)	0.82***	(0.10)	1.15***	(0.10)	0.83***	(0.10)	1.13***	(0.17)
Adjustment coefficient (ϕ)	-0.30***	(0.11)	-0.37***	(0.11)	-0.50***	(0.13)	-0.42***	(0.11)	-0.56***	(0.13)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.37***	(0.09)	-0.38***	(0.09)	-0.33***	(0.10)	-0.34***	(0.09)	-0.27**	(0.11)
$\Delta ln(Y)_{t-2}$	-0.41***	(0.07)	-0.31***	(0.09)	-0.26***	(0.09)	-0.23***	(0.08)	-0.25***	(0.08)
$\Delta ln(Y)_{t-3}$	-0.22***	(0.06)	-0.21***	(0.06)	-0.14**	(0.05)	-0.15***	(0.05)	-0.11**	(0.05)
$\Delta ln(NEER)_{t}$	0.24	(0.16)	0.18	(0.17)	0.49**	(0.17)	0.46**	(0.20)	0.38*	(0.20)
$\Delta ln(NEER)_{t-1}$	0.20	(0.15)	0.03	(0.15)	0.21	(0.18)	0.18	(0.16)	0.06	(0.21)
$\Delta ln(NEER)_{t-2}$	0.03	(0.17)	-0.09	(0.20)	-0.17	(0.20)	-0.01	(0.20)	-0.39	(0.30)
$\Delta ln(NEER)_{t-3}$	-0.22*	(0.13)	-0.11	(0.17)	-0.33**	(0.16)	-0.29*	(0.17)	-0.55***	(0.19)
$\Delta ln(REGDP)_{t}$	0.54**	(0.17)	0.62***	(0.17)	0.75***	(0.20)	0.63***	(0.18)	0.40	(0.27)
$\Delta ln(REGDP)_{t-1}$	0.74***	(0.16)	0.48***	(0.18)	0.49*	(0.25)	0.58**	(0.23)	0.63*	(0.35)
$\Delta ln(REGDP)_{t-2}$	0.51**	(0.14)	0.53***	(0.19)	0.73***	(0.25)	0.73***	(0.24)	0.45	(0.31)
$\Delta ln(REGDP)_{t-3}$	1.04***	(0.16)	0.57***	(0.15)	1.12***	(0.23)	0.96***	(0.21)	0.96***	(0.34)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

exchange rates. Therefore, my results have to be interpreted as aggregate elasticities for all tourist groups. In that sense, my estimates reflect the actual situation of the tourism sector by taking into account the possibility of substitution across tourists from different countries of origin. In Switzerland, this has been a very important factor lately. In 2014 for example, the depreciation of the euro led to a decline in tourists coming from the Euro Area. However, this reduction was compensated by an increase in overnight stays by tourists from Asia and Switzerland (see Tagesanzeiger 2015), which resulted in an overall positive growth rate of Swiss tourism in 2014. This implies that it is important to consider all tourist groups at the same time when analyzing the general situation of the tourism sector.

3.4.2 Robustness Checks

In this subsection, I perform several robustness checks. I refer to the results from my baseline specification reported in the previous subsection as my benchmark to which I compare the findings from the robustness exercises. Every robustness check reports two tables: the results for real exchange rates and the results for nominal exchange rates. All corresponding regression tables are collected in the Appendix.

Different Normalization of GDP

In my first robustness check, I explore the impact of different GDP normalization procedures on my estimates. As indicated in Section 3.2.2, initial real GDP can be normalized in different ways. In my benchmark specification, I set PPP-adjusted GDP per capita of the US to 100 in the year 1999. In this robustness check, I use PPP-adjusted aggregate instead of per capita GDP. Tables 3.A.4 and 3.A.5 demonstrate that the exchange rate elasticity estimates and adjustment coefficients from my baseline specification are robust.

In a second robustness check, I normalize real GDP for every country of origin to 100 in the year 1999. In doing so, I do not have to make any assumptions about how to compare different levels of GDP across countries. Moreover, they are completely independent of past exchange rates. I again find that my exchange rate elasticity estimates from the baseline specification are robust (see Tables 3.A.6 and 3.A.7).

Weights with Eight Lags

Tables 3.A.8 and 3.A.9 report results for the baseline specification when I use eight instead of four lags in my weighting procedure. All exchange rate elasticity coefficients remain highly significant and are in the same range as in the benchmark case.

Removing Business Cantons

One might suspect that my results are biased due to cantons that are visited by many business travelers. This group of tourists is expected to be less sensitive to classical determinants of tourism demand. Instead, the decision to take a business trip rather depends on company-specific or general macroeconomic factors. Therefore, I perform a robustness check in which I exclude the cantons with the three largest cities in Switzerland, i.e. the canton of Basel-Stadt, the canton of Genf, and the canton of Zürich. The corresponding results are presented in Tables 3.A.10 and 3.A.11. All in all, the results are robust. If anything, the exchange rate elasticities and the adjustment speed slightly increase after removing business cantons. This confirms the intuition that business travelers react less to exchange rates than the average tourist. However, quantitatively, the impact on the coefficients is very small, and I thus conclude that my benchmark results are robust to the exclusion of the cantons with the three largest cities in Switzerland.

Excluding Tourists from Japan and Russia

In my benchmark estimation, I only include tourists from countries whose share in total Swiss tourism exceeds three percent. In this robustness check, I increase this cutoff to five percent, which leads to the exclusion of Japan and Russia. The results from my baseline specification are largely unaffected by this new cutoff (see Tables 3.A.12 and 3.A.13). Overall, this provides further evidence for the conclusion that my baseline estimates are robust.

Constant Exchange Rate for Swiss Tourists

When computing the exchange rate basket for every canton, I have to make an assumption about the exchange rate faced by Swiss tourists. In the benchmark case, I use a weighted average of the exchange rates of the Swiss franc against the currencies of the most important Swiss tourism destinations. Alternatively, one might assume that travel decisions of Swiss tourists within Switzerland are not affected by exchange rates. In this robustness check, I therefore hold the exchange rate for Swiss tourists constant at 100 for all points in time. Tables 3.A.14 and 3.A.15 report the corresponding results, which yield roughly identical exchange rate coefficients as in the benchmark case. The adjustment coefficients are also highly robust in both cases.

Ex-Ante Fixed Shares

One might be worried that my weights are endogenous because they are allowed to change over time. To some extent, this concern is mitigated by the fact that I use a minimum of four lags of the shares when I construct the weights. Nevertheless, I conduct a robustness check in which I use constant average shares of the year 2003 as weights in my calculation of $REGDP$, $REER$, and $NEER$. The results for the baseline specification with these ex-ante fixed shares are presented in Tables 3.A.16 and 3.A.17. The estimated exchange rate elasticities are largely unchanged.

Time Fixed Effects

In my last robustness check, I introduce time fixed effects into Equation (3.14). The corresponding estimation results for real exchange rates are presented in Table 3.A.18. In that case, the exchange rate elasticity estimates for all but one variable become insignificant. For overnight stays, the sign of the coefficient reverses and is now equal to -2.70 and highly significant. The estimated adjustment speed increases slightly for all variables, but is in general still in the same range as in the baseline estimation. The pattern is similar for nominal exchange rates. Results in Table 3.A.19 reveal significantly negative nominal exchange rate elasticity estimates for arrivals, overnight stays, and room occupancy rates, whereas the coefficients for bed occupancy rates and revenues per available room are not significant. The adjustment coefficients are again in the same range as in the benchmark specification.

The negative long-run exchange rate elasticities that I find for the specification with time fixed effects are highly implausible. They suggest that an appreciation of the Swiss franc attracts more tourists, which contradicts basic economic theories of demand. In the following section, I therefore discuss possible explanations for this sign reversal.

3.5 Discussion

The previous subsection documents that my benchmark results are highly robust to alternative measures of explanatory variables and to a number of different specifications. However, once I add time fixed effects, most coefficients become insignificant or negative. In the following, I show that this counterintuitive result is driven by the fact that there is a large common component in effective exchange rates across cantons. After removing this common factor by introducing time fixed effects, the variation is no longer sufficient to identify the relationship between exchange rates and tourism.

Some illustrative evidence for this argument is presented in Figures 3.3 and 3.4. From these plots, it becomes apparent that there is a large common component in real and nominal effective exchange rates of different cantons. Panel summary statistics reported in Table 3.8 confirm this finding. The standard deviation between cantons is very small relative to the one within cantons. Thus, most of the variation in effective exchange rates comes from within cantons. Furthermore, the overall and the within variances are almost identical.

Table 3.8: Summary statistics for effective exchange rates

		Mean	**Std. Dev.**	**Minimum**	**Maximum**
	overall	100.8511	5.432827	85.74796	112.306
REER	between		0.628873	99.60287	102.5921
	within		5.397679	86.99615	111.2945
	overall	91.39194	7.462152	72.82052	101.7629
NEER	between		1.749884	87.20607	94.16369
	within		7.261973	77.00639	103.3001

Together with the fact that there is substantial variation in the shares of different tourist groups across cantons (as shown in Table 3.1), the above findings suggest that there must be an important common factor driving bilateral Swiss franc exchange rates. Interestingly, this is exactly what previous research documents. Specifically, the literature argues that the Swiss franc is a safe haven currency (see e.g. Grisse and Nitschka 2013, Hoffmann and Suter 2010, and Ranaldo and Söderlind 2010). A typical characteristic of such a currency is that its bilateral exchange rates respond to global shocks, which can lead to a comovement between them.[23] For this reason, most of the variation in effective exchange rates is common to all cantons, making the specification with time fixed effects too demanding for the data at hand.

In Section 3.A.2 in the Appendix, I further strengthen this argument by documenting that the coefficients from the estimation with time fixed effects are highly unstable and very sensitive to small changes in the data. For this purpose, I conduct all of the robustness checks from the previous section for the case with time fixed effects. Depending on the specification, the effects explode, disappear, or even reverse. In some cases, the estimates for real and nominal exchange rates furthermore contradict each other. This confirms that there is an identification problem inherent in the estimation with time fixed effects.

It is worth emphasizing that it is only the parameters of the cointegration equation and not the adjustment coefficients that become unstable in the estimation with time fixed effects. This leads to the conjecture that the non-stationarity in the data is mostly driven by the common component in bilateral exchange rates.

[23]Hoffmann and Suter (2010) document that the Swiss franc was a safe haven currency with respect to the US and Canadian dollar and with respect to the British pound in the time period between 1990 and 2009. Moreover, Grisse and Nitschka (2013) find that in the recent past, the Swiss franc appreciated against the euro and traditional carry trade currencies in times of increased global uncertainty.

The fact that I cannot control for time fixed effects might raise concerns about a possible omitted variable bias caused by unobserved aggregate variables that affect all cantons in the same way. However, due to the super-consistency property of the parameters from cointegration regressions, omitted variables should not be a problem in my setting. As demonstrated by Stock (1987), the estimator of the cointegration coefficients converges to its true value much faster than estimators from regressions with stationary time series.[24] Thus, it is not necessary to include any stationary variables in the cointegration relationship. Nevertheless, since this is an asymptotic result, there might still be a bias in finite samples. Therefore, in Section 3.A.3 in the Appendix, I conduct an exercise that disentangles the relative importance of the average exchange rate and possible omitted variables. I document that all real exchange rate elasticities from the estimation with time fixed effects can be replicated by simply including the average real exchange rate over all cantons as an additional explanatory variable in the baseline estimation without time fixed effects. The same is true in the case of nominal exchange rates for arrivals and overnight stays. This suggests that for these variables, there is no major omitted variable bias in my baseline estimation, even if I do not control for time fixed effects.

Based on these findings, I conclude that the exchange rate elasticity estimates from my baseline specification are reliable even without controlling for time fixed effects.[25] They are largely unbiased and highly robust.

3.6 Conclusion

In this paper, I estimate exchange rate elasticities for tourism in Switzerland. For this purpose, I use quarterly panel data across cantons, ranging from 2005 to 2013. Each canton's effective exchange rate is defined as a weighted average of bilateral exchange rates, using past shares of tourists from different countries of origin as a measure of exposure. The presence of a cointegration relationship between my variables allows me to analyze the effect of exchange rate fluctuations on Swiss tourism using a panel error correction model. Identification is based on the assumption that short-run dynamics are canton-specific, whereas long-run coefficients are common to all cantons.

In my baseline estimation, I allow for canton fixed effects and a linear time trend. I find real (nominal) long-run exchange rate elasticities of 1.03 (0.60) for tourist arrivals, 0.49 (0.47) for overnight stays, 0.82 (0.92) and 0.84 (0.85) for bed and room occupancy rates respectively, and 1.54 (0.87) for revenues per available room. The estimated adjustment

[24] Specifically, cointegration estimators converge at a rate of T^1, whereas standard OLS estimators for stationary time series converge at a rate of $T^{1/2}$.

[25] The fact that I do not include time fixed effects in my estimation does not mean that I simply pool the data. In particular, I allow for canton-specific adjustment coefficients and short-run dynamics.

speed ranges from 30 to 56 percent. My results are highly robust to alternative weighting schemes and to various specifications.

I furthermore show that there is a strong common factor driving effective exchange rates of all cantons. Therefore, it is not possible to control for time fixed effects. There is simply not enough variation left after removing the common component by introducing time dummies. However, based on the super-consistency property of cointegration parameters, my baseline estimates without time fixed effects should be free of any omitted variable bias. In order to mitigate concerns about the fact that this asymptotic result might not hold in my finite sample, I additionally conduct an exercise which shows that my baseline results are indeed reliable and largely unbiased.

My findings have several policy implications. First of all, it is important to note that my exchange rate elasticities for overnight stays are at the lower bound of existing estimates. An important reason for this is that I use an entire exchange rate basket, whereas the previous literature focuses on bilateral exchange rates only. In doing so, my approach accounts for the possibility of substitution across different tourist groups. This suggests that cantons are to some extent able to absorb the negative effects of an appreciation of the Swiss franc by changing the composition of the tourists that they attract. However, this practice quickly reaches its limit. The reason for this lies in the second policy implication. Specifically, my findings show that even though tourist shares vary substantially across cantons, there is a large common component in effective exchange rates that affects all cantons at the same time. This implies that policies aimed at the mitigation of the adverse effects of the strong Swiss franc on tourism should tackle the problem on a more aggregate level.

3.A Appendix

3.A.1 Data

Table 3.A.1: Data sources for explanatory variables

Country	**Exchange Rate**	**Consumer Price Index**	**Real GDP**
Switzerland	Swiss National Bank (2015)	OECD (2015a)	OECD (2015b)
Euro Area	Swiss National Bank (2015)	Eurostat (2015b)	Eurostat (2015a)
United Kingdom	Swiss National Bank (2015)	OECD (2015a)	Eurostat (2015a)
United States	Swiss National Bank (2015)	OECD (2015a)	Eurostat (2015a)
India	Swiss National Bank (2015)	OECD (2015a)	World Bank (2015a)
China	Bloomberg (2015)	OECD (2015a)	National Bureau of Statistics of China (2015)
Japan	Bloomberg (2015)	OECD (2015a)	OECD (2015b)
Russia	Swiss National Bank (2015)	OECD (2015a)	OECD (2015b)

In the following, I address a few additional issues concerning my data.

- **Exchange Rates:**
  Daily and monthly data are converted to a quarterly frequency by taking averages over the entire time period.

- **Real GDP:**
  For India, only yearly GDP is available. I linearly interpolate the missing values in order to get quarterly data.

- **Euro Area:**
  The Euro Area is continuously expanding. For my analysis, it is important that I refer to the same group of countries for the entire time period. Therefore, I use the definition of the Euro Area as of 2001. This includes the following twelve countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. My measure ignores Slovenia (joined in 2007), Cyprus and Malta (joined in 2008), Slovakia (joined in 2009), Estonia (joined in

2011), and Latvia (joined in 2014). However, the share of these countries in total overnight stays of tourists from the Euro Area only amounts to 1.3 percent in 2014 and is therefore negligible.

3.A.2 Robustness Checks with Time Fixed Effects

The goal of this section is to shed more light on the origin of the counterintuitive results found in the estimation with time fixed effects. For this purpose, I redo all my robustness checks for the specification with time fixed effects. For the sake of clarity, I do not compare the coefficients from the robustness checks with time fixed effects to the benchmark results without time fixed effects. Therefore, in this section, the term 'benchmark' always refers to the original specification with time fixed effects, as reported in Tables 3.A.18 and 3.A.19.

Different Normalization of GDP

If I rely on aggregate instead of per capita GDP in my normalization, most of the coefficients change their sign or significance level compared to the benchmark results with time fixed effects (see Tables 3.A.20 and 3.A.21). In the benchmark specification with time fixed effects for real exchange rates, the only coefficient that is significantly different from zero is the elasticity for overnight stays. With this alternative normalization technique, the opposite is the case. The exchange rate elasticity for overnight stays is estimated to be -0.04 (compared to -2.70 in the benchmark case), whereas the coefficients for arrivals and room occupancy rates become significant. Furthermore, their sign is reversed. The real exchange rate elasticity for arrivals is equal to -1.09 (compared to 0.37 in the benchmark case), and for room occupancy rates it is equal to 1.34 (compared to -0.29 in the benchmark case). For nominal exchange rates, the picture looks similar. A small change in the normalization of real GDP leads to a large shift in the coefficients when I include time fixed effects.

If I normalize GDP for every country of origin to 100 in the year 1999, then the change in the coefficients in the estimation with time fixed effects is even more extreme than under the previous alternative normalization. The corresponding results for real and nominal exchange rates are presented in Tables 3.A.22 and 3.A.23. As opposed to the benchmark estimates with time fixed effects, I now find positive exchange rate elasticities for all variables. They are highly significant for arrivals and overnight stays in the specification with real exchange rates and for occupancy rates in the case of nominal exchange rates.

Thus, with time fixed effects, the resulting exchange rate elasticities vary dramatically depending on the normalization technique used, whereas the adjustment coefficients do not change.

Weights with Eight Lags

The use of eight instead of four lags in my weighting procedure does not have a large impact on the results for real exchange rates, as is shown in Table 3.A.24. However, the estimated nominal exchange rate elasticities displayed in Table 3.A.25 differ substantially from the benchmark results with time fixed effects. Specifically, some of them are no longer significantly different from zero, whereas others suddenly become significant. Adjustment coefficients, on the other hand, are highly robust.

Removing Business Cantons

Removing business cantons from my sample does not change the coefficients compared to the estimation with time fixed effects, as is shown in Tables 3.A.26 and 3.A.27.

Excluding Tourists from Japan and Russia

In this robustness check, I exclude Japan and Russia from tourists' countries of origin by raising the cutoff of the share in total Swiss tourism from three to five percent. As reported in Tables 3.A.28 and 3.A.29, this has an effect on some coefficients in the estimation with time fixed effects compared to the benchmark. Specifically, the exchange rate elasticity for revenues per available room becomes highly significant and positive for both nominal and real exchange rates, whereas the coefficient on nominal exchange rates for room occupancy rates becomes insignificant. The adjustment coefficients are not affected. Overall, this provides further evidence for the conclusion that my estimates with time fixed effects are not robust.

Constant Exchange Rate for Swiss Tourists

Holding the Swiss franc exchange rate faced by Swiss tourists constant at 100 leads to changes in the coefficients for real exchange rates, as is documented in Table 3.A.30. While in the benchmark case with time fixed effects exchange rate elasticities for occupancy rates are found to be close to zero and insignificant, they are now significantly negative. For nominal exchange rates, on the other hand, the estimates are roughly identical to the ones from the benchmark case with time fixed effects (see Table 3.A.31).

Ex-Ante Fixed Shares

In this last robustness check, I fix the weights used in the calculation of the explanatory variables on their average level from the year 2003. Tables 3.A.32 and 3.A.33 show that with this specification, the coefficients on the real exchange rate for occupancy rates and revenues per available room explode. The elasticities range between 7 and 14 percent. For nominal exchange rates, the coefficients on the latter two variables increase as well, but not as extremely as in the case with real exchange rates. The exchange rate elasticity for arrivals turns highly negative. All in all, the results for real and nominal exchange rates have contradicting implications for tourism. The adjustment speed, on the other hand, is highly robust in both specifications.

Conclusion

The findings from this section confirm that there is an identification problem inherent in the specification with time fixed effects. The coefficient estimates are highly unstable and sensitive to small changes in the data. Given that the baseline results from the benchmark estimation *without* time fixed effects are very robust (as demonstrated in Section 3.4.2), this suggests that the identification problem in the specification *with* time fixed effects is driven by the fact that most of the variation in effective exchange rates is common to all cantons. This issue is further discussed in Section 3.5.

3.A.3 Test for Omitted Variables

In this subsection, I conduct an exercise to disentangle the effects of aggregate (average) exchange rates and potential omitted variables. My approach is based on the following argument. If there were no omitted variables on the aggregate level, then time fixed effects would simply capture the common component in the effective exchange rates of all cantons. In that case, an estimation with time fixed effects would be equivalent to a specification that controls for the average effective exchange rate across all cantons at every point in time. If both models – the one with time fixed effects and the one with the average effective exchange rate as an additional control – yield the same coefficient estimates, then this can be interpreted as evidence for the fact that there are no major omitted variables present on the aggregate level.

In order to perform this exercise, I first compute the average of effective exchange rates over all cantons at every point in time:

$$AVREER_t = \frac{1}{26}\sum_{i=1}^{26} REER_{i,t} \tag{3.A.1}$$

$$AVNEER_t = \frac{1}{26}\sum_{i=1}^{26} NEER_{i,t} \tag{3.A.2}$$

In a next step, I include $AVREER$ and $AVNEER$ as an additional explanatory variable in my baseline specification for real and nominal exchange rates respectively.

The results for the real exchange rate are given in Table 3.A.34. The coefficients on the canton-specific effective exchange rates are remarkably similar to the ones from the estimation with time fixed effects. Consider, for example, the real exchange rate elasticity for overnight stays. In the specification with time fixed effects (see Table 3.A.18), it is significantly negative and equal to -2.70. If I control for $AVREER$ instead of time fixed effects, the resulting coefficient is -2.91. The exchange rate elasticities for the other four dependent variables are insignificant in both models. The fact that I can replicate the pattern of coefficient estimates from the specification with time fixed effects by simply including the average effective exchange rate as a control confirms that there are no major omitted variables on the aggregate level. This is reassuring because it suggests that I am able to identify the unbiased real exchange rate elasticities in my baseline specification without including time fixed effects.

The results for nominal exchange rates are reported in Table 3.A.35. For arrivals and overnight stays, I am again able to replicate the significantly negative coefficients from my specification with time fixed effects (see Table 3.A.19) by simply including $AVNEER$ as a control variable. Thus, my nominal exchange rate elasticities for arrivals and overnight stays from my estimation without time fixed effects do not seem to be subject to a major omitted variable bias. For occupancy rates and revenues per available room, the picture is less clear. Whereas time fixed effects lead to insignificant coefficients for the bed occupancy rate and revenues per available room, the specification with $AVNEER$ yields significantly negative estimates for these variables. For the room occupancy rate, the opposite is the case. Thus, some caution is required when interpreting the nominal exchange rate elasticities for occupancy rates and revenues per available room.

The fact that I can replicate almost all coefficients from the specification with time fixed effects simply by controlling for average effective exchange rates mitigates concerns about potential omitted variables on the aggregate level.

3.A.4 Tables

Table 3.A.2: Cointegration tests for baseline specification with trend

	Real Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-3.10	(0.00)	-3.99	(0.00)	-3.71	(0.00)	-3.67	(0.00)	-3.05	(0.00)
G_α	-14.47	(0.28)	-19.61	(0.00)	-18.67	(0.00)	-19.28	(0.00)	-12.39	(0.81)
P_τ	-14.65	(0.00)	-16.65	(0.00)	-15.92	(0.00)	-16.38	(0.00)	-13.09	(0.06)
P_α	-17.13	(0.00)	-20.67	(0.00)	-20.48	(0.00)	-22.27	(0.00)	-16.81	(0.00)
	Nominal Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-3.35	(0.00)	-4.10	(0.00)	-3.79	(0.00)	-3.46	(0.00)	-2.91	(0.01)
G_α	-15.53	(0.09)	-20.35	(0.00)	-19.17	(0.00)	-19.28	(0.00)	-12.59	(0.77)
P_τ	-15.32	(0.00)	-17.71	(0.00)	-16.85	(0.00)	-17.15	(0.00)	-13.49	(0.02)
P_α	-17.78	(0.00)	-21.99	(0.00)	-21.33	(0.00)	-22.68	(0.00)	-16.16	(0.00)

Notes: Test statistics from the panel data cointegration tests by Westerlund (2007) including a canton-specific constant and a linear time trend. Lag length determined by the Akaike information criterion. p-values in parentheses. Under the null hypothesis, the variables are not cointegrated.

Table 3.A.3: Cointegration tests for specification with time fixed effects and trend

	Real Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-3.38	(0.00)	-3.31	(0.00)	-3.40	(0.00)	-3.07	(0.00)	-3.09	(0.00)
G_α	-17.29	(0.01)	-18.17	(0.00)	-19.02	(0.00)	-17.78	(0.00)	-13.52	(0.53)
P_τ	-18.09	(0.00)	-18.05	(0.00)	-17.98	(0.00)	-17.47	(0.00)	-14.63	(0.00)
P_α	-19.66	(0.00)	-20.60	(0.00)	-20.90	(0.00)	-19.31	(0.00)	-14.93	(0.00)
	Nominal Effective Exchange Rate									
	Arrivals		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Value	p	Value	p	Value	p	Value	p	Value	p
G_τ	-3.28	(0.00)	-3.23	(0.00)	-3.23	(0.00)	-3.40	(0.00)	-2.94	(0.01)
G_α	-17.12	(0.01)	-17.87	(0.00)	-18.77	(0.00)	-19.58	(0.00)	-11.33	(0.95)
P_τ	-17.40	(0.00)	-17.97	(0.00)	-17.31	(0.00)	-16.95	(0.00)	-10.64	(0.87)
P_α	-18.91	(0.00)	-20.74	(0.00)	-20.29	(0.00)	-19.42	(0.00)	-9.75	(0.71)

Notes: Test statistics from the panel data cointegration tests by Westerlund (2007) including a canton-specific constant, a linear time trend, and time fixed effects. Lag length determined by the Akaike information criterion. p-values in parentheses. Under the null hypothesis, the variables are not cointegrated.

Table 3.A.4: Baseline results for real exchange rates with normalization based on aggregate GDP

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.61***	(0.11)	0.38***	(0.08)	0.78***	(0.10)	0.48***	(0.09)	1.38***	(0.14)
$ln(REGDP)_{t-1}$	-0.45***	(0.12)	0.37***	(0.07)	-0.29***	(0.09)	0.40***	(0.08)	-0.06	(0.11)
Adjustment coefficient (ϕ)	-0.31***	(0.06)	-0.42***	(0.11)	-0.45***	(0.06)	-0.44***	(0.11)	-0.51***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.35***	(0.06)	-0.29***	(0.08)	-0.25***	(0.06)	-0.26***	(0.08)	-0.25***	(0.08)
$\Delta ln(Y)_{t-2}$	-0.34***	(0.07)	-0.23***	(0.07)	-0.14	(0.08)	-0.15**	(0.07)	-0.14*	(0.08)
$\Delta ln(Y)_{t-3}$	-0.24***	(0.06)	-0.18***	(0.06)	-0.05	(0.05)	-0.09	(0.06)	-0.06	(0.05)
$\Delta ln(REER)_{t}$	0.07	(0.17)	0.15	(0.13)	0.28*	(0.16)	0.17	(0.15)	0.45**	(0.20)
$\Delta ln(REER)_{t-1}$	0.08	(0.16)	-0.07	(0.13)	0.07	(0.16)	-0.05	(0.15)	-0.10	(0.17)
$\Delta ln(REER)_{t-2}$	-0.05	(0.18)	0.01	(0.19)	-0.20	(0.18)	0.02	(0.19)	-0.68**	(0.27)
$\Delta ln(REER)_{t-3}$	-0.09	(0.13)	-0.02	(0.14)	-0.23**	(0.09)	-0.19*	(0.12)	-0.60***	(0.19)
$\Delta ln(REGDP)_{t}$	0.39**	(0.17)	0.52***	(0.13)	0.01	(0.17)	0.45***	(0.16)	0.05	(0.21)
$\Delta ln(REGDP)_{t-1}$	0.36**	(0.15)	0.19	(0.14)	0.28**	(0.14)	0.12	(0.13)	0.16	(0.31)
$\Delta ln(REGDP)_{t-2}$	0.14	(0.10)	0.09	(0.13)	0.37***	(0.11)	-0.03	(0.15)	0.58***	(0.20)
$\Delta ln(REGDP)_{t-3}$	0.43***	(0.12)	0.18	(0.12)	0.43***	(0.13)	0.08	(0.12)	0.41*	(0.21)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.5: Baseline results for nominal exchange rates with normalization based on aggregate GDP

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	0.64***	(0.13)	0.48***	(0.08)	0.91***	(0.12)	0.75***	(0.14)	1.00***	(0.09)
$ln(REGDP)_{t-1}$	-0.57***	(0.14)	0.16***	(0.06)	-0.45***	(0.12)	-0.54***	(0.15)	0.50***	(0.12)
Adjustment coefficient (ϕ)	-0.29***	(0.06)	-0.43***	(0.08)	-0.40***	(0.06)	-0.31***	(0.05)	-0.59***	(0.15)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.36***	(0.06)	-0.29***	(0.07)	-0.29***	(0.06)	-0.36***	(0.05)	-0.18	(0.12)
$\Delta ln(Y)_{t-2}$	-0.36***	(0.07)	-0.24***	(0.07)	-0.17**	(0.09)	-0.24***	(0.08)	-0.09	(0.10)
$\Delta ln(Y)_{t-3}$	-0.25***	(0.05)	-0.18***	(0.06)	-0.08	(0.05)	-0.15**	(0.06)	-0.03	(0.05)
$\Delta ln(NEER)_{t}$	0.07	(0.18)	0.14	(0.15)	0.33*	(0.17)	0.30	(0.21)	0.30	(0.21)
$\Delta ln(NEER)_{t-1}$	0.14	(0.17)	-0.09	(0.15)	0.15	(0.16)	0.10	(0.16)	0.06	(0.22)
$\Delta ln(NEER)_{t-2}$	-0.05	(0.21)	-0.04	(0.19)	-0.18	(0.21)	0.02	(0.20)	-0.61*	(0.33)
$\Delta ln(NEER)_{t-3}$	-0.04	(0.13)	-0.01	(0.14)	-0.17	(0.11)	-0.07	(0.13)	-0.45**	(0.20)
$\Delta ln(REGDP)_{t}$	0.39**	(0.17)	0.48***	(0.13)	0.00	(0.17)	0.15	(0.16)	0.18	(0.21)
$\Delta ln(REGDP)_{t-1}$	0.38**	(0.15)	0.24*	(0.13)	0.32**	(0.14)	0.44**	(0.14)	-0.06	(0.33)
$\Delta ln(REGDP)_{t-2}$	0.15	(0.10)	0.12	(0.13)	0.41***	(0.11)	0.32***	(0.12)	0.44**	(0.18)
$\Delta ln(REGDP)_{t-3}$	0.45***	(0.12)	0.21**	(0.11)	0.48***	(0.13)	0.55***	(0.12)	0.13	(0.25)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.6: Baseline results for real exchange rates with normalization of initial GDP to 100

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.95***	(0.11)	0.89***	(0.07)	0.97***	(0.08)	1.00***	(0.08)	1.35***	(0.12)
$ln(REGDP)_{t-1}$	0.12	(0.18)	0.42***	(0.07)	0.14	(0.10)	0.20**	(0.09)	0.29***	(0.10)
Adjustment coefficient (ϕ)	-0.41***	(0.09)	-0.47***	(0.11)	-0.48***	(0.10)	-0.45***	(0.11)	-0.56***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.33***	(0.06)	-0.34***	(0.08)	-0.34***	(0.07)	-0.34***	(0.08)	-0.29***	(0.09)
$\Delta ln(Y)_{t-2}$	-0.38***	(0.06)	-0.30***	(0.06)	-0.26***	(0.05)	-0.24***	(0.05)	-0.25***	(0.06)
$\Delta ln(Y)_{t-3}$	-0.25***	(0.05)	-0.23***	(0.06)	-0.16***	(0.05)	-0.19***	(0.05)	-0.13**	(0.05)
$\Delta ln(REER)_{t}$	-0.03	(0.15)	-0.02	(0.16)	0.12	(0.14)	0.12	(0.16)	0.32*	(0.17)
$\Delta ln(REER)_{t-1}$	-0.16	(0.14)	-0.41**	(0.17)	-0.17	(0.15)	-0.25	(0.15)	-0.34*	(0.14)
$\Delta ln(REER)_{t-2}$	-0.24	(0.16)	-0.46***	(0.13)	-0.38**	(0.16)	-0.30*	(0.17)	-0.75***	(0.24)
$\Delta ln(REER)_{t-3}$	-0.40***	(0.13)	-0.40***	(0.10)	-0.42***	(0.06)	-0.44***	(0.10)	-0.83***	(0.14)
$\Delta ln(REGDP)_{t}$	0.50***	(0.16)	0.72***	(0.15)	0.66***	(0.20)	0.63***	(0.19)	0.52*	(0.27)
$\Delta ln(REGDP)_{t-1}$	0.60***	(0.20)	0.55***	(0.16)	0.67***	(0.23)	0.61***	(0.23)	0.79**	(0.32)
$\Delta ln(REGDP)_{t-2}$	0.27*	(0.16)	0.58***	(0.18)	0.75***	(0.23)	0.64***	(0.23)	0.90***	(0.29)
$\Delta ln(REGDP)_{t-3}$	0.62***	(0.15)	0.41**	(0.18)	0.63***	(0.22)	0.46**	(0.23)	1.08***	(0.36)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.7: Baseline results for nominal exchange rates with normalization of initial GDP to 100

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	1.00***	(0.10)	0.83***	(0.06)	0.95***	(0.07)	0.93***	(0.08)	1.13***	(0.14)
$ln(REGDP)_{t-1}$	0.22	(0.16)	0.68***	(0.06)	0.53***	(0.08)	0.66***	(0.09)	0.37**	(0.16)
Adjustment coefficient (ϕ)	-0.42***	(0.10)	-0.50***	(0.12)	-0.51***	(0.11)	-0.43***	(0.11)	-0.53***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.32***	(0.07)	-0.31***	(0.08)	-0.32***	(0.07)	-0.35***	(0.08)	-0.33***	(0.09)
$\Delta ln(Y)_{t-2}$	-0.39***	(0.06)	-0.28***	(0.07)	-0.26***	(0.05)	-0.26***	(0.05)	-0.28***	(0.06)
$\Delta ln(Y)_{t-3}$	-0.25***	(0.05)	-0.23***	(0.06)	-0.18***	(0.05)	-0.20***	(0.06)	-0.15***	(0.05)
$\Delta ln(NEER)_{t}$	0.00	(0.17)	-0.05	(0.17)	0.13	(0.16)	0.09	(0.19)	0.24	(0.18)
$\Delta ln(NEER)_{t-1}$	-0.13	(0.14)	-0.34**	(0.15)	-0.11	(0.14)	-0.14	(0.15)	-0.10	(0.16)
$\Delta ln(NEER)_{t-2}$	-0.22	(0.18)	-0.41***	(0.15)	-0.39**	(0.16)	-0.25	(0.19)	-0.65**	(0.29)
$\Delta ln(NEER)_{t-3}$	-0.39**	(0.15)	-0.30**	(0.13)	-0.38***	(0.07)	-0.35***	(0.13)	-0.68***	(0.14)
$\Delta ln(REGDP)_{t}$	0.50***	(0.16)	0.74***	(0.15)	0.69***	(0.21)	0.68***	(0.19)	0.57**	(0.27)
$\Delta ln(REGDP)_{t-1}$	0.57***	(0.21)	0.42**	(0.17)	0.53**	(0.25)	0.46*	(0.24)	0.74**	(0.33)
$\Delta ln(REGDP)_{t-2}$	0.26	(0.16)	0.51***	(0.19)	0.64***	(0.25)	0.53**	(0.25)	0.94***	(0.31)
$\Delta ln(REGDP)_{t-3}$	0.60***	(0.16)	0.33*	(0.18)	0.53**	(0.23)	0.35	(0.25)	0.93**	(0.38)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.8: Baseline results for real exchange rates using weights with eight lags

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.58***	(0.08)	0.53***	(0.09)	0.91***	(0.08)	0.77***	(0.07)	1.13***	(0.13)
$ln(REGDP)_{t-1}$	0.09	(0.14)	0.66***	(0.14)	0.47***	(0.15)	0.75***	(0.11)	0.28	(0.23)
Adjustment coefficient (ϕ)	-0.27***	(0.10)	-0.34***	(0.09)	-0.45***	(0.11)	-0.41***	(0.10)	-0.51***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.39***	(0.09)	-0.40***	(0.08)	-0.38***	(0.08)	-0.34***	(0.08)	-0.33***	(0.09)
$\Delta ln(Y)_{t-2}$	-0.43***	(0.07)	-0.33***	(0.08)	-0.28***	(0.05)	-0.24***	(0.08)	-0.28***	(0.06)
$\Delta ln(Y)_{t-3}$	-0.24***	(0.06)	0.72***	(0.06)	-0.18***	(0.05)	-0.15***	(0.05)	-0.14***	(0.05)
$\Delta ln(REER)_{t}$	0.12	(0.15)	0.12	(0.15)	0.16	(0.13)	0.27	(0.16)	0.28*	(0.16)
$\Delta ln(REER)_{t-1}$	0.12	(0.15)	-0.05	(0.15)	-0.04	(0.14)	0.04	(0.14)	-0.12	(0.14)
$\Delta ln(REER)_{t-2}$	0.03	(0.17)	-0.08	(0.19)	-0.20	(0.17)	-0.05	(0.19)	-0.46	(0.28)
$\Delta ln(REER)_{t-3}$	-0.17	(0.12)	-0.13	(0.16)	-0.28***	(0.08)	-0.24*	(0.15)	-0.58***	(0.16)
$\Delta ln(REGDP)_{t}$	0.66***	(0.16)	0.72***	(0.17)	0.65***	(0.20)	0.75***	(0.17)	0.70**	(0.30)
$\Delta ln(REGDP)_{t-1}$	0.76***	(0.16)	0.45***	(0.15)	0.60**	(0.25)	0.55***	(0.21)	0.87***	(0.31)
$\Delta ln(REGDP)_{t-2}$	0.44***	(0.15)	0.57***	(0.16)	0.72***	(0.25)	0.78***	(0.21)	0.87***	(0.29)
$\Delta ln(REGDP)_{t-3}$	1.02***	(0.14)	0.64***	(0.13)	0.66***	(0.22)	0.88***	(0.15)	1.03***	(0.31)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.9: Baseline results for nominal exchange rates using weights with eight lags

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	0.57***	(0.06)	0.51***	(0.08)	0.81***	(0.09)	0.81***	(0.06)	1.10***	(0.13)
$ln(REGDP)_{t-1}$	0.20*	(0.11)	0.73***	(0.12)	0.77***	(0.17)	0.83***	(0.11)	0.42*	(0.23)
Adjustment coefficient (ϕ)	-0.28***	(0.11)	-0.37***	(0.10)	-0.39***	(0.11)	-0.46***	(0.11)	-0.48***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.39***	(0.09)	-0.39***	(0.08)	-0.42***	(0.08)	-0.32***	(0.09)	-0.37***	(0.09)
$\Delta ln(Y)_{t-2}$	-0.43***	(0.07)	-0.33***	(0.08)	-0.32***	(0.05)	-0.22**	(0.09)	-0.30***	(0.06)
$\Delta ln(Y)_{t-3}$	-0.24***	(0.06)	-0.22***	(0.06)	-0.20***	(0.04)	-0.14**	(0.06)	-0.16***	(0.05)
$\Delta ln(NEER)_t$	0.19	(0.17)	0.16	(0.17)	0.16	(0.15)	0.38*	(0.20)	0.32*	(0.18)
$\Delta ln(NEER)_{t-1}$	0.13	(0.15)	-0.01	(0.15)	0.07	(0.13)	0.07	(0.15)	0.02	(0.14)
$\Delta ln(NEER)_{t-2}$	0.04	(0.19)	-0.08	(0.21)	-0.14	(0.20)	-0.05	(0.21)	-0.43	(0.31)
$\Delta ln(NEER)_{t-3}$	-0.21	(0.14)	-0.11	(0.17)	-0.21**	(0.10)	-0.25	(0.17)	-0.53***	(0.16)
$\Delta ln(REGDP)_t$	0.69***	(0.16)	0.73***	(0.17)	0.72***	(0.21)	0.74***	(0.17)	0.73**	(0.29)
$\Delta ln(REGDP)_{t-1}$	0.76***	(0.16)	0.43***	(0.15)	0.57**	(0.26)	0.50**	(0.22)	0.85**	(0.33)
$\Delta ln(REGDP)_{t-2}$	0.41**	(0.16)	0.56***	(0.16)	0.67**	(0.27)	0.74***	(0.22)	0.86***	(0.30)
$\Delta ln(REGDP)_{t-3}$	1.05***	(0.15)	0.63***	(0.14)	0.63***	(0.23)	0.92***	(0.16)	0.98***	(0.33)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.10: Basline results for real exchange rates excluding business cantons

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	1.01***	(0.12)	0.49***	(0.07)	0.89***	(0.10)	0.86***	(0.06)	1.56***	(0.10)
$ln(REGDP)_{t-1}$	-0.05	(0.21)	0.76***	(0.11)	1.38***	(0.14)	0.83***	(0.10)	-0.23*	(0.14)
Adjustment coefficient (ϕ)	-0.41***	(0.09)	-0.38***	(0.11)	-0.43***	(0.10)	-0.39***	(0.12)	-0.52***	(0.13)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.28***	(0.06)	-0.37***	(0.09)	-0.39***	(0.09)	-0.37***	(0.09)	-0.30***	(0.12)
$\Delta ln(Y)_{t-2}$	-0.35***	(0.06)	-0.29***	(0.09)	-0.30***	(0.06)	-0.24***	(0.08)	-0.28***	(0.07)
$\Delta ln(Y)_{t-3}$	-0.21***	(0.04)	-0.19***	(0.06)	-0.18***	(0.05)	-0.16***	(0.05)	-0.15***	(0.05)
$\Delta ln(REER)_{t}$	0.07	(0.16)	0.13	(0.16)	0.29**	(0.13)	0.33*	(0.18)	0.53***	(0.18)
$\Delta ln(REER)_{t-1}$	-0.03	(0.16)	0.01	(0.15)	0.19*	(0.11)	0.15	(0.16)	-0.20	(0.23)
$\Delta ln(REER)_{t-2}$	-0.14	(0.17)	-0.10	(0.20)	-0.10	(0.18)	-0.06	(0.21)	-0.46*	(0.28)
$\Delta ln(REER)_{t-3}$	-0.37***	(0.14)	-0.12	(0.18)	-0.32***	(0.12)	-0.30*	(0.18)	-0.76***	(0.20)
$\Delta ln(REGDP)_{t}$	0.31**	(0.14)	0.61***	(0.13)	0.79***	(0.21)	0.63***	(0.17)	0.38	(0.33)
$\Delta ln(REGDP)_{t-1}$	0.63***	(0.21)	0.50***	(0.17)	0.56*	(0.29)	0.63***	(0.23)	1.31***	(0.33)
$\Delta ln(REGDP)_{t-2}$	0.33**	(0.15)	0.59***	(0.20)	0.74**	(0.31)	0.86***	(0.25)	1.05***	(0.32)
$\Delta ln(REGDP)_{t-3}$	0.74***	(0.15)	0.59***	(0.17)	0.88***	(0.26)	0.92***	(0.22)	1.48***	(0.34)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	736		736		736		736		644	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.11: Baseline results for nominal exchange rates excluding business cantons

Long-run coefficients										
$ln(NEER)_{t-1}$	1.02***	(0.10)	0.51***	(0.07)	0.93***	(0.06)	0.87***	(0.06)	1.10***	(0.16)
$ln(REGDP)_{t-1}$	0.08	(0.19)	0.54***	(0.12)	1.18***	(0.11)	0.85***	(0.10)	0.41*	(0.25)
Adjustment coefficient (ϕ)	-0.42***	(0.11)	-0.44***	(0.12)	-0.53***	(0.14)	-0.43***	(0.13)	-0.44***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.28***	(0.07)	-0.35***	(0.09)	-0.32***	(0.12)	-0.35***	(0.10)	-0.38***	(0.11)
$\Delta ln(Y)_{t-2}$	-0.35***	(0.06)	-0.28***	(0.08)	-0.26***	(0.10)	-0.23**	(0.09)	-0.33***	(0.07)
$\Delta ln(Y)_{t-3}$	-0.21***	(0.04)	-0.20***	(0.07)	-0.13**	(0.06)	-0.15**	(0.06)	-0.18***	(0.05)
$\Delta ln(NEER)_{t}$	0.10	(0.17)	0.08	(0.17)	0.45**	(0.18)	0.41*	(0.21)	0.39*	(0.20)
$\Delta ln(NEER)_{t-1}$	0.01	(0.16)	0.02	(0.14)	0.26	(0.20)	0.22	(0.17)	0.13	(0.21)
$\Delta ln(NEER)_{t-2}$	-0.10	(0.19)	-0.08	(0.20)	-0.17	(0.23)	-0.01	(0.22)	-0.21	(0.33)
$\Delta ln(NEER)_{t-3}$	-0.37**	(0.16)	-0.05	(0.17)	-0.32*	(0.18)	-0.27	(0.19)	-0.58***	(0.18)
$\Delta ln(REGDP)_{t}$	0.33**	(0.14)	0.61***	(0.13)	0.74***	(0.19)	0.60***	(0.17)	0.55*	(0.31)
$\Delta ln(REGDP)_{t-1}$	0.62***	(0.22)	0.52***	(0.19)	0.44*	(0.26)	0.58**	(0.25)	1.12***	(0.37)
$\Delta ln(REGDP)_{t-2}$	0.29*	(0.16)	0.60***	(0.22)	0.77***	(0.28)	0.81***	(0.26)	0.84**	(0.34)
$\Delta ln(REGDP)_{t-3}$	0.72***	(0.16)	0.46***	(0.16)	1.10***	(0.26)	0.93***	(0.24)	1.24***	(0.38)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	736		736		736		736		644	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.12: Baseline results for real exchange rates excluding tourists from Japan and Russia

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.64***	(0.07)	0.49***	(0.07)	0.81***	(0.09)	0.85***	(0.06)	1.58***	(0.10)
$ln(REGDP)_{t-1}$	0.05	(0.13)	0.73***	(0.12)	1.40***	(0.14)	0.78***	(0.12)	-0.22	(0.14)
Adjustment coefficient (ϕ)	-0.29***	(0.10)	-0.34***	(0.09)	-0.42***	(0.09)	-0.38***	(0.10)	-0.51***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.38***	(0.08)	-0.39***	(0.08)	-0.39***	(0.08)	-0.35***	(0.07)	-0.31***	(0.10)
$\Delta ln(Y)_{t-2}$	-0.42***	(0.07)	-0.32***	(0.08)	-0.30***	(0.06)	-0.25***	(0.07)	-0.28***	(0.07)
$\Delta ln(Y)_{t-3}$	-0.22***	(0.06)	-0.21***	(0.06)	-0.19***	(0.05)	-0.16***	(0.05)	-0.13**	(0.05)
$\Delta ln(REER)_{t}$	0.18	(0.15)	0.16	(0.15)	0.29**	(0.12)	0.37**	(0.17)	0.57***	(0.17)
$\Delta ln(REER)_{t-1}$	0.15	(0.15)	0.00	(0.14)	0.15	(0.11)	0.14	(0.15)	-0.19	(0.19)
$\Delta ln(REER)_{t-2}$	0.02	(0.15)	-0.08	(0.18)	-0.07	(0.16)	-0.02	(0.19)	-0.54**	(0.25)
$\Delta ln(REER)_{t-3}$	-0.22*	(0.12)	-0.17	(0.16)	-0.33***	(0.11)	-0.31**	(0.15)	-0.82***	(0.17)
$\Delta ln(REGDP)_{t}$	0.55***	(0.17)	0.65***	(0.17)	0.82***	(0.22)	0.67***	(0.18)	0.34	(0.30)
$\Delta ln(REGDP)_{t-1}$	0.77***	(0.17)	0.54***	(0.17)	0.57**	(0.28)	0.62***	(0.22)	1.25***	(0.31)
$\Delta ln(REGDP)_{t-2}$	0.52***	(0.14)	0.55***	(0.19)	0.67**	(0.28)	0.77***	(0.22)	0.97***	(0.29)
$\Delta ln(REGDP)_{t-3}$	1.06***	(0.16)	0.64***	(0.15)	0.87***	(0.23)	0.95***	(0.19)	1.45***	(0.31)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.13: Baseline results for nominal exchange rates excluding tourists from Japan and Russia

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	0.61***	(0.05)	0.46***	(0.06)	0.94***	(0.06)	0.86***	(0.06)	0.96***	(0.14)
$ln(REGDP)_{t-1}$	0.16	(0.11)	0.56***	(0.11)	1.22***	(0.11)	0.83***	(0.11)	0.52**	(0.23)
Adjustment coefficient (ϕ)	-0.29***	(0.11)	-0.41***	(0.11)	-0.50***	(0.13)	-0.40***	(0.11)	-0.46***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.38***	(0.09)	-0.37***	(0.08)	-0.33***	(0.10)	-0.35***	(0.08)	-0.38***	(0.10)
$\Delta ln(Y)_{t-2}$	-0.42***	(0.07)	-0.31***	(0.08)	-0.27***	(0.09)	-0.24***	(0.08)	-0.31***	(0.07)
$\Delta ln(Y)_{t-3}$	-0.23***	(0.06)	-0.22***	(0.07)	-0.15***	(0.06)	-0.16***	(0.06)	-0.16***	(0.05)
$\Delta ln(NEER)_{t}$	0.25	(0.16)	0.12	(0.16)	0.49***	(0.16)	0.46**	(0.20)	0.39**	(0.19)
$\Delta ln(NEER)_{t-1}$	0.20	(0.15)	-0.02	(0.14)	0.20	(0.18)	0.19	(0.16)	0.09	(0.18)
$\Delta ln(NEER)_{t-2}$	0.04	(0.17)	-0.10	(0.18)	-0.17	(0.20)	-0.01	(0.20)	-0.33	(0.30)
$\Delta ln(NEER)_{t-3}$	-0.23*	(0.13)	-0.12	(0.16)	-0.35**	(0.16)	-0.30*	(0.17)	-0.63***	(0.16)
$\Delta ln(REGDP)_{t}$	0.56***	(0.17)	0.65***	(0.17)	0.77***	(0.20)	0.63***	(0.18)	0.50*	(0.28)
$\Delta ln(REGDP)_{t-1}$	0.76***	(0.17)	0.56***	(0.19)	0.50*	(0.26)	0.60**	(0.24)	1.03***	(0.35)
$\Delta ln(REGDP)_{t-2}$	0.50***	(0.14)	0.55***	(0.21)	0.72***	(0.25)	0.74***	(0.23)	0.74**	(0.31)
$\Delta ln(REGDP)_{t-3}$	1.06***	(0.16)	0.52***	(0.15)	1.12***	(0.23)	0.96***	(0.21)	1.14***	(0.34)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.14: Baseline results for real exchange rates with a constant exchange rate for Swiss tourists

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.85***	(0.09)	0.63***	(0.09)	0.56***	(0.08)	1.19***	(0.08)	1.28***	(0.15)
$ln(REGDP)_{t-1}$	0.07	(0.12)	0.69***	(0.11)	1.10***	(0.13)	0.73***	(0.10)	0.89	(0.17)
Adjustment coefficient (ϕ)	-0.28***	(0.10)	-0.33***	(0.10)	-0.45***	(0.10)	-0.40***	(0.11)	-0.53***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.38***	(0.08)	-0.40***	(0.08)	-0.35***	(0.08)	-0.35***	(0.08)	-0.28***	(0.10)
$\Delta ln(Y)_{t-2}$	-0.43***	(0.07)	-0.32***	(0.08)	-0.27***	(0.07)	-0.25***	(0.08)	-0.27***	(0.08)
$\Delta ln(Y)_{t-3}$	-0.23***	(0.05)	-0.22***	(0.06)	-0.15***	(0.05)	-0.16***	(0.05)	-0.12**	(0.05)
$\Delta ln(REER)_{t}$	0.34	(0.47)	0.28	(0.40)	0.32	(0.27)	0.64	(0.43)	0.35	(0.38)
$\Delta ln(REER)_{t-1}$	0.45	(0.41)	-0.06	(0.29)	0.44	(0.28)	0.15	(0.23)	-0.13	(0.27)
$\Delta ln(REER)_{t-2}$	-0.05	(0.34)	-0.18	(0.38)	-0.20	(0.38)	-0.05	(0.38)	-0.60	(0.50)
$\Delta ln(REER)_{t-3}$	-0.43	(0.29)	-0.22	(0.35)	-0.17	(0.19)	-0.41	(0.34)	-0.80***	(0.31)
$\Delta ln(REGDP)_{t}$	0.56***	(0.16)	0.62***	(0.17)	0.73***	(0.21)	0.66***	(0.18)	0.42	(0.27)
$\Delta ln(REGDP)_{t-1}$	0.75***	(0.16)	0.53***	(0.17)	0.54**	(0.25)	0.63***	(0.23)	0.78**	(0.33)
$\Delta ln(REGDP)_{t-2}$	0.53***	(0.14)	0.57***	(0.18)	0.69***	(0.27)	0.78***	(0.24)	0.57*	(0.30)
$\Delta ln(REGDP)_{t-3}$	1.01***	(0.16)	0.61***	(0.16)	0.81***	(0.22)	0.91***	(0.20)	1.03***	(0.31)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.15: Baseline results for nominal exchange rates with a constant exchange rate for Swiss tourists

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	0.67***	(0.07)	0.62***	(0.07)	1.33***	(0.11)	1.34***	(0.07)	1.02***	(0.13)
$ln(REGDP)_{t-1}$	0.17	(0.11)	0.72***	(0.10)	0.95***	(0.14)	0.70***	(0.09)	1.04***	(0.17)
Adjustment coefficient (ϕ)	-0.27***	(0.10)	-0.35***	(0.11)	-0.41***	(0.12)	-0.43***	(0.12)	-0.49***	(0.12)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.39***	(0.08)	-0.40***	(0.09)	-0.39***	(0.10)	-0.33***	(0.10)	-0.32***	(0.11)
$\Delta ln(Y)_{t-2}$	-0.42***	(0.07)	-0.32***	(0.08)	-0.30***	(0.09)	-0.23**	(0.09)	-0.30***	(0.08)
$\Delta ln(Y)_{t-3}$	-0.24***	(0.05)	-0.22***	(0.06)	-0.16***	(0.06)	-0.15***	(0.06)	-0.14***	(0.05)
$\Delta ln(NEER)_{t}$	0.44	(0.52)	0.33	(0.49)	0.84*	(0.43)	0.82	(0.54)	0.28	(0.40)
$\Delta ln(NEER)_{t-1}$	0.63	(0.43)	-0.02	(0.39)	0.59	(0.39)	0.09	(0.34)	0.08	(0.37)
$\Delta ln(NEER)_{t-2}$	-0.10	(0.47)	-0.22	(0.47)	-0.41	(0.59)	-0.12	(0.43)	-0.69	(0.62)
$\Delta ln(NEER)_{t-3}$	-0.39	(0.31)	-0.05	(0.37)	-0.16	(0.31)	-0.33	(0.45)	-0.55	(0.35)
$\Delta ln(REGDP)_{t}$	0.56***	(0.16)	0.61***	(0.17)	0.75***	(0.21)	0.58***	(0.20)	0.45*	(0.27)
$\Delta ln(REGDP)_{t-1}$	0.73***	(0.16)	0.50***	(0.17)	0.60**	(0.26)	0.56**	(0.25)	0.73**	(0.35)
$\Delta ln(REGDP)_{t-2}$	0.53***	(0.14)	0.57***	(0.19)	0.81***	(0.26)	0.75***	(0.25)	0.54	(0.30)
$\Delta ln(REGDP)_{t-3}$	0.96***	(0.16)	0.54***	(0.15)	1.04***	(0.23)	0.90***	(0.22)	0.90***	(0.33)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.16: Baseline results for real exchange rates with ex-ante fixed shares

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.54***	(0.07)	0.76***	(0.09)	0.95***	(0.10)	0.77***	(0.07)	0.97***	(0.12)
$ln(REGDP)_{t-1}$	0.26**	(0.13)	0.49***	(0.18)	0.69***	(0.21)	0.85***	(0.13)	1.00***	(0.21)
Adjustment coefficient (ϕ)	-0.30***	(0.10)	-0.31***	(0.09)	-0.35***	(0.10)	-0.41***	(0.11)	-0.54***	(0.12)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.38***	(0.09)	-0.44***	(0.08)	-0.45***	(0.08)	-0.34***	(0.08)	-0.29***	(0.10)
$\Delta ln(Y)_{t-2}$	-0.43***	(0.07)	-0.37***	(0.07)	-0.35***	(0.05)	-0.24***	(0.08)	-0.26***	(0.08)
$\Delta ln(Y)_{t-3}$	-0.24***	(0.06)	-0.24***	(0.06)	-0.23***	(0.05)	-0.15***	(0.05)	-0.12**	(0.06)
$\Delta ln(REER)_{t}$	0.17	(0.16)	0.26*	(0.14)	0.18	(0.13)	0.35**	(0.18)	0.35	(0.18)
$\Delta ln(REER)_{t-1}$	0.12	(0.14)	0.00	(0.13)	-0.03	(0.15)	0.06	(0.14)	-0.10	(0.16)
$\Delta ln(REER)_{t-2}$	0.02	(0.17)	-0.08	(0.20)	-0.22	(0.18)	-0.05	(0.21)	-0.48	(0.31)
$\Delta ln(REER)_{t-3}$	-0.22*	(0.12)	-0.19	(0.15)	-0.35***	(0.07)	-0.28*	(0.15)	-0.68***	(0.18)
$\Delta ln(REGDP)_{t}$	0.76***	(0.18)	0.79***	(0.17)	0.85***	(0.22)	0.77***	(0.18)	0.67**	(0.29)
$\Delta ln(REGDP)_{t-1}$	0.86***	(0.18)	0.68***	(0.18)	0.86***	(0.29)	0.66***	(0.24)	0.84**	(0.36)
$\Delta ln(REGDP)_{t-2}$	0.57***	(0.16)	0.75***	(0.19)	0.86***	(0.29)	0.81***	(0.22)	0.81***	(0.29)
$\Delta ln(REGDP)_{t-3}$	1.10***	(0.16)	0.84***	(0.16)	0.77***	(0.26)	0.90***	(0.17)	1.14***	(0.34)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.17: Baseline results for nominal exchange rates with ex-ante fixed shares

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	0.56***	(0.06)	0.71***	(0.07)	0.98***	(0.11)	0.81***	(0.07)	0.89***	(0.10)
$ln(REGDP)_{t-1}$	0.35***	(0.11)	0.67***	(0.14)	0.80***	(0.22)	0.91***	(0.14)	1.28***	(0.19)
Adjustment coefficient (ϕ)	-0.31***	(0.11)	-0.33***	(0.11)	-0.30***	(0.10)	-0.42***	(0.11)	-0.58***	(0.13)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.39***	(0.09)	-0.44***	(0.09)	-0.49***	(0.08)	-0.34***	(0.09)	-0.25**	(0.11)
$\Delta ln(Y)_{t-2}$	-0.44***	(0.08)	-0.37***	(0.08)	-0.39***	(0.05)	-0.24***	(0.08)	-0.24***	(0.09)
$\Delta ln(Y)_{t-3}$	-0.25***	(0.06)	-0.25***	(0.06)	-0.25***	(0.05)	-0.15***	(0.06)	-0.11*	(0.06)
$\Delta ln(NEER)_{t}$	0.25	(0.17)	0.31*	(0.16)	0.22	(0.14)	0.46**	(0.20)	0.41**	(0.20)
$\Delta ln(NEER)_{t-1}$	0.15	(0.14)	0.07	(0.14)	0.06	(0.14)	0.12	(0.14)	-0.01	(0.18)
$\Delta ln(NEER)_{t-2}$	0.04	(0.18)	-0.04	(0.21)	-0.18	(0.21)	-0.01	(0.22)	-0.47	(0.33)
$\Delta ln(NEER)_{t-3}$	-0.26**	(0.13)	-0.15	(0.17)	-0.31***	(0.08)	-0.28*	(0.17)	-0.65***	(0.18)
$\Delta ln(REGDP)_{t}$	0.76***	(0.18)	0.80***	(0.17)	0.89***	(0.22)	0.78***	(0.18)	0.64**	(0.28)
$\Delta ln(REGDP)_{t-1}$	0.85***	(0.18)	0.62***	(0.19)	0.90***	(0.30)	0.65**	(0.26)	0.67*	(0.38)
$\Delta ln(REGDP)_{t-2}$	0.56***	(0.16)	0.72***	(0.20)	0.87***	(0.29)	0.81***	(0.23)	0.68**	(0.29)
$\Delta ln(REGDP)_{t-3}$	1.12***	(0.16)	0.81***	(0.17)	0.80***	(0.26)	0.97***	(0.19)	1.05***	(0.37)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.18: Results for real exchange rates with time fixed effects

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.37	(0.42)	-2.70***	(0.34)	0.14	(0.39)	-0.29	(0.51)	0.10	(0.51)
$ln(REGDP)_{t-1}$	-2.28***	(0.29)	2.15***	(0.40)	1.33***	(0.35)	0.20	(0.42)	0.43	(0.46)
Adjustment coefficient (ϕ)	-0.42***	(0.07)	-0.37***	(0.07)	-0.48***	(0.06)	-0.43***	(0.06)	-0.55***	(0.09)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.21***	(0.05)	-0.29***	(0.06)	-0.21***	(0.06)	-0.24***	(0.05)	-0.17**	(0.07)
$\Delta ln(Y)_{t-2}$	-0.19***	(0.04)	-0.18***	(0.04)	-0.16***	(0.04)	-0.15***	(0.04)	-0.13***	(0.04)
$\Delta ln(REER)_t$	0.54	(0.74)	0.24	(1.23)	0.68	(1.05)	0.81	(1.00)	-0.02	(1.56)
$\Delta ln(REER)_{t-1}$	-0.67	(0.95)	0.04	(0.80)	0.33	(0.72)	0.37	(0.70)	-0.04	(1.07)
$\Delta ln(REER)_{t-2}$	-0.40	(0.83)	-0.38	(0.71)	-0.69	(0.84)	-0.81	(0.84)	-1.32	(1.12)
$\Delta ln(REGDP)_t$	-0.57	(0.54)	0.10	(0.72)	0.19	(0.60)	-0.13	(0.73)	-1.36	(1.12)
$\Delta ln(REGDP)_{t-1}$	0.69	(0.61)	0.16	(0.62)	0.13	(0.61)	0.55	(0.53)	0.87	(0.87)
$\Delta ln(REGDP)_{t-2}$	1.12***	(0.43)	-1.04*	(0.54)	-0.43	(0.70)	-0.19	(0.73)	-0.80	(0.73)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.19: Results for nominal exchange rates with time fixed effects

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-0.82***	(0.28)	-0.81***	(0.21)	-0.02	(0.20)	-0.39**	(0.19)	0.41	(0.28)
$ln(REGDP)_{t-1}$	-1.64***	(0.39)	0.76**	(0.31)	1.02***	(0.37)	0.71	(0.46)	0.14	(0.39)
Adjustment coefficient (ϕ)	-0.39***	(0.07)	-0.39***	(0.07)	-0.47***	(0.06)	-0.41***	(0.07)	-0.59***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.20***	(0.05)	-0.24***	(0.06)	-0.19***	(0.06)	-0.22***	(0.05)	-0.13	(0.08)
$\Delta ln(Y)_{t-2}$	-0.18***	(0.04)	-0.15***	(0.04)	-0.15***	(0.04)	-0.15***	(0.04)	-0.12**	(0.05)
$\Delta ln(NEER)_t$	-0.03	(1.08)	-0.14	(0.87)	-0.98	(0.91)	-0.82	(0.92)	-0.96	(1.55)
$\Delta ln(NEER)_{t-1}$	-0.52	(1.47)	-0.41	(1.51)	-0.15	(1.39)	-0.10	(1.44)	-1.41	(1.92)
$\Delta ln(NEER)_{t-2}$	1.30	(1.07)	-0.75	(1.09)	-0.54	(0.96)	-0.55	(1.20)	-2.94**	(1.33)
$\Delta ln(REGDP)_t$	-0.84*	(0.46)	-0.27	(0.69)	0.02	(0.62)	-0.03	(0.73)	-0.69	(1.32)
$\Delta ln(REGDP)_{t-1}$	0.55	(0.57)	0.62	(0.59)	0.28	(0.64)	0.65	(0.53)	1.10	(0.90)
$\Delta ln(REGDP)_{t-2}$	0.61	(0.41)	-0.52	(0.47)	-0.24	(0.62)	-0.12	(0.60)	-0.16	(0.83)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.20: Results for real exchange rates with time fixed effects and normalization based on aggregate GDP

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	-1.09**	(0.43)	-0.04	(0.30)	0.13	(0.44)	1.34**	(0.53)	-0.29	(0.57)
$ln(REGDP)_{t-1}$	0.44***	(0.06)	0.20***	(0.07)	-0.17**	(0.08)	0.26	(0.08)	0.09	(0.07)
Adjustment coefficient (ϕ)	-0.37***	(0.08)	-0.41***	(0.09)	-0.44***	(0.07)	-0.46***	(0.07)	-0.55***	(0.09)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.24***	(0.06)	-0.26***	(0.06)	-0.23***	(0.06)	-0.23***	(0.06)	-0.19***	(0.07)
$\Delta ln(Y)_{t-2}$	-0.20***	(0.04)	-0.15***	(0.05)	-0.16***	(0.04)	-0.13***	(0.05)	-0.13***	(0.04)
$\Delta ln(REER)_{t}$	0.35	(0.70)	1.13	(1.15)	0.83	(1.03)	1.38	(1.01)	1.12	(1.54)
$\Delta ln(REER)_{t-1}$	-0.07	(0.72)	-0.79	(0.79)	0.36	(0.79)	-0.05	(0.73)	-0.08	(1.12)
$\Delta ln(REER)_{t-2}$	-0.21	(0.68)	-1.07	(0.70)	-0.74	(0.94)	-1.14	(0.96)	-1.00	(1.29)
$\Delta ln(REGDP)_{t}$	0.26*	(0.14)	0.27	(0.18)	0.07	(0.17)	0.18	(0.22)	0.12	(0.36)
$\Delta ln(REGDP)_{t-1}$	-0.13	(0.16)	-0.20	(0.15)	-0.14	(0.15)	-0.25*	(0.14)	-0.46*	(0.25)
$\Delta ln(REGDP)_{t-2}$	-0.07	(0.14)	0.10	(0.17)	0.20	(0.17)	0.06	(0.18)	0.18	(0.21)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.21: Results for nominal exchange rates with time fixed effects and normalization based on aggregate GDP

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-1.52***	(0.17)	-0.13	(0.15)	0.23	(0.24)	1.09***	(0.33)	0.28	(0.31)
$ln(REGDP)_{t-1}$	0.09	(0.06)	0.18***	(0.07)	-0.15**	(0.07)	0.27***	(0.07)	0.02	(0.07)
Adjustment coefficient (ϕ)	-0.41***	(0.08)	-0.41***	(0.08)	-0.45***	(0.07)	-0.46***	(0.08)	-0.58***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.20***	(0.06)	-0.25***	(0.06)	-0.23***	(0.05)	-0.21***	(0.06)	-0.16**	(0.08)
$\Delta ln(Y)_{t-2}$	-0.17***	(0.04)	-0.15***	(0.04)	-0.16***	(0.04)	-0.13***	(0.05)	-0.12**	(0.04)
$\Delta ln(NEER)_t$	-0.18	(1.27)	-0.28	(0.99)	-0.59	(1.15)	-0.26	(1.14)	-0.25	(1.38)
$\Delta ln(NEER)_{t-1}$	-0.43	(1.62)	-0.76	(1.59)	-0.05	(1.46)	-0.40	(1.46)	-1.34	(1.52)
$\Delta ln(NEER)_{t-2}$	1.79	(1.35)	-0.88	(1.43)	0.01	(1.77)	-0.35	(1.88)	-1.75	(1.51)
$\Delta ln(REGDP)_t$	0.16	(0.13)	0.25	(0.17)	0.08	(0.16)	0.19	(0.21)	-0.04	(0.31)
$\Delta ln(REGDP)_{t-1}$	-0.17	(0.16)	-0.26**	(0.13)	-0.13	(0.13)	-0.23*	(0.14)	-0.31	(0.22)
$\Delta ln(REGDP)_{t-2}$	0.03	(0.19)	0.09	(0.20)	0.20	(0.17)	0.10	(0.17)	0.25	(0.22)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.22: Results for real exchange rates with time fixed effects and normalization of initial GDP to 100

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	1.51***	(0.43)	0.99**	(0.44)	0.09	(0.56)	0.40	(0.54)	0.51	(0.47)
$ln(REGDP)_{t-1}$	0.79***	(0.17)	-0.59***	(0.15)	0.07	(0.19)	0.38**	(0.20)	0.08	(0.19)
Adjustment coefficient (ϕ)	-0.47***	(0.07)	-0.51***	(0.07)	-0.52***	(0.05)	-0.52***	(0.06)	-0.62***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.20***	(0.06)	-0.21***	(0.06)	-0.19***	(0.05)	-0.19***	(0.05)	-0.14*	(0.07)
$\Delta ln(Y)_{t-2}$	-0.19***	(0.04)	-0.14***	(0.05)	-0.14***	(0.04)	-0.12***	(0.04)	-0.13***	(0.04)
$\Delta ln(REER)_{t}$	0.23	(0.72)	0.65	(1.09)	-0.08	(1.00)	-0.11	(0.89)	0.26	(1.38)
$\Delta ln(REER)_{t-1}$	-0.93	(0.83)	-0.35	(0.83)	0.91	(1.00)	0.41	(0.86)	-0.36	(1.12)
$\Delta ln(REER)_{t-2}$	-0.49	(0.84)	-1.03**	(0.43)	-0.26	(1.02)	-0.70	(0.99)	-0.82	(1.32)
$\Delta ln(REGDP)_{t}$	1.00	(0.98)	1.71**	(0.85)	2.39**	(1.01)	0.38**	(1.07)	1.38	(1.40)
$\Delta ln(REGDP)_{t-1}$	-0.82	(0.99)	-1.20	(0.95)	-1.13*	(0.63)	-0.68	(0.67)	-1.78*	(0.98)
$\Delta ln(REGDP)_{t-2}$	-0.13	(0.93)	1.07	(1.48)	0.90	(1.29)	1.30	(1.34)	1.93	(1.84)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.23: Results for nominal exchange rates with time fixed effects and normalization of initial GDP to 100

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	0.23	(0.22)	0.43*	(0.23)	1.12***	(0.27)	1.29***	(0.26)	0.45*	(0.26)
$ln(REGDP)_{t-1}$	1.32***	(0.20)	-0.64***	(0.16)	0.24	(0.18)	0.72***	(0.19)	0.16	(0.17)
Adjustment coefficient (ϕ)	-0.46***	(0.08)	-0.48***	(0.07)	-0.54***	(0.06)	-0.53***	(0.07)	-0.68***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.19***	(0.06)	-0.21***	(0.06)	-0.16***	(0.05)	-0.16***	(0.06)	-0.09	(0.09)
$\Delta ln(Y)_{t-2}$	-0.18***	(0.05)	-0.14***	(0.05)	-0.13***	(0.04)	-0.11**	(0.04)	-0.11**	(0.05)
$\Delta ln(NEER)_t$	-0.86	(1.08)	-0.27	(0.93)	-0.49	(1.05)	-0.40	(1.06)	-0.58	(1.25)
$\Delta ln(NEER)_{t-1}$	-0.65	(1.40)	-0.37	(1.43)	-0.30	(1.47)	-0.34	(1.39)	-1.22	(1.82)
$\Delta ln(NEER)_{t-2}$	0.59	(1.34)	-1.07	(1.18)	-0.71	(1.51)	-1.11	(1.57)	-2.86**	(1.36)
$\Delta ln(REGDP)_t$	1.03	(0.91)	2.08***	(0.79)	2.42***	(0.90)	2.47**	(0.98)	1.32	(1.42)
$\Delta ln(REGDP)_{t-1}$	-0.81	(1.04)	-1.00	(0.97)	-1.13	(0.80)	-0.83	(0.77)	-2.31**	(1.05)
$\Delta ln(REGDP)_{t-2}$	-0.68	(0.88)	0.76	(1.38)	0.98	(1.20)	1.08	(1.25)	1.50	(1.75)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.24: Results for real exchange rates with time fixed effects using weights with eight lags

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.30	(0.40)	-1.12**	(0.44)	0.41	(0.41)	-0.33	(0.39)	0.16	(0.49)
$ln(REGDP)_{t-1}$	-2.21***	(0.28)	1.66***	(0.34)	0.25	(0.27)	-1.17***	(0.30)	0.13	(0.41)
Adjustment coefficient (ϕ)	-0.39***	(0.07)	-0.36***	(0.08)	-0.49***	(0.06)	-0.46***	(0.08)	-0.57***	(0.09)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.20***	(0.06)	-0.26***	(0.07)	-0.18***	(0.06)	-0.20***	(0.05)	-0.14**	(0.07)
$\Delta ln(Y)_{t-2}$	-0.20***	(0.04)	-0.17***	(0.06)	-0.15***	(0.04)	-0.14***	(0.04)	-0.14***	(0.04)
$\Delta ln(REER)_{t}$	0.27	(0.75)	0.16	(0.97)	0.58	(1.28)	0.61	(1.39)	0.84	(1.30)
$\Delta ln(REER)_{t-1}$	0.47	(1.04)	0.25	(1.35)	0.36	(0.85)	0.03	(1.02)	-0.41	(1.57)
$\Delta ln(REER)_{t-2}$	0.89	(0.91)	0.61	(1.40)	0.08	(1.57)	-0.07	(1.39)	-1.32	(1.20)
$\Delta ln(REGDP)_{t}$	-0.26	(0.65)	0.97	(0.78)	1.01	(0.77)	0.33	(0.86)	1.05	(0.78)
$\Delta ln(REGDP)_{t-1}$	0.54	(0.56)	-1.00	(0.70)	-0.54	(0.66)	-0.30	(0.67)	-1.08	(0.83)
$\Delta ln(REGDP)_{t-2}$	0.72	(0.45)	0.07	(0.58)	1.17**	(0.55)	1.51**	(0.59)	0.94	(0.78)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.25: Results for nominal exchange rates with time fixed effects using weights with eight lags

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-1.05***	(0.24)	-0.10	(0.20)	0.38	(0.24)	-0.27	(0.19)	0.55*	(0.28)
$ln(REGDP)_{t-1}$	-0.83***	(0.31)	1.82***	(0.34)	-0.08	(0.27)	-1.01***	(0.31)	-0.20	(0.39)
Adjustment coefficient (ϕ)	-0.42***	(0.08)	-0.37***	(0.07)	-0.50***	(0.06)	-0.46***	(0.07)	-0.62***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.18***	(0.06)	-0.27***	(0.06)	-0.18***	(0.05)	-0.21***	(0.05)	-0.12	(0.07)
$\Delta ln(Y)_{t-2}$	-0.17***	(0.04)	-0.17***	(0.06)	-0.14***	(0.04)	-0.12***	(0.04)	-0.11**	(0.05)
$\Delta ln(NEER)_t$	-1.17	(1.08)	-1.14	(1.07)	-0.55	(0.87)	-0.59	(0.97)	-1.31	(1.88)
$\Delta ln(NEER)_{t-1}$	1.21**	(0.50)	1.03	(0.63)	2.34**	(1.11)	2.15*	(1.19)	2.37	(1.76)
$\Delta ln(NEER)_{t-2}$	0.92	(1.03)	-0.57	(1.39)	0.11	(2.53)	0.19	(2.57)	-0.91	(2.50)
$\Delta ln(REGDP)_t$	0.06	(0.63)	0.94	(0.77)	0.75	(0.78)	0.07	(0.78)	0.53	(0.80)
$\Delta ln(REGDP)_{t-1}$	0.09	(0.46)	-0.72	(0.58)	-0.55	(0.63)	-0.21	(0.66)	-0.69	(0.93)
$\Delta ln(REGDP)_{t-2}$	0.19	(0.53)	-0.25	(0.65)	1.01*	(0.61)	1.22**	(0.58)	1.07	(1.00)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.26: Results for real exchange rates with time fixed effects excluding business cantons

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.45	(0.42)	-2.56***	(0.36)	-0.33	(0.42)	-0.80	(0.52)	-0.75	(0.65)
$ln(REGDP)_{t-1}$	-2.14***	(0.28)	2.32***	(0.42)	0.95***	(0.37)	-1.20***	(0.45)	0.75	(0.47)
Adjustment coefficient (ϕ)	-0.45***	(0.08)	-0.39***	(0.07)	-0.50***	(0.07)	-0.45***	(0.07)	-0.55***	(0.08)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.21***	(0.06)	-0.29***	(0.06)	-0.20***	(0.07)	-0.23***	(0.05)	-0.17**	(0.08)
$\Delta ln(Y)_{t-2}$	-0.16***	(0.04)	-0.16***	(0.04)	-0.14***	(0.04)	-0.13***	(0.04)	-0.12**	(0.05)
$\Delta ln(REER)_{t}$	0.61	(0.84)	0.24	(1.39)	0.57	(1.19)	0.69	(1.12)	-0.40	(1.78)
$\Delta ln(REER)_{t-1}$	-0.86	(1.07)	-0.31	(0.87)	0.29	(0.78)	0.36	(0.75)	0.02	(1.24)
$\Delta ln(REER)_{t-2}$	-0.58	(0.94)	-0.47	(0.81)	-0.61	(0.94)	-0.60	(0.90)	-0.89	(1.22)
$\Delta ln(REGDP)_{t}$	-0.62	(0.58)	0.15	(0.78)	0.24	(0.67)	-0.36	(0.82)	-1.00	(1.23)
$\Delta ln(REGDP)_{t-1}$	0.89	(0.65)	0.29	(0.69)	0.36	(0.68)	1.11*	(0.58)	1.40	(0.85)
$\Delta ln(REGDP)_{t-2}$	1.29***	(0.45)	-1.15*	(0.61)	-0.32	(0.79)	0.28	(0.80)	-0.55	(0.79)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	759		759		759		759		667	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.27: Results for nominal exchange rates with time fixed effects excluding business cantons

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-0.60**	(0.28)	-0.73***	(0.21)	-0.09	(0.20)	-0.39*	(0.22)	0.29	(0.36)
$ln(REGDP)_{t-1}$	-1.66***	(0.38)	0.69**	(0.31)	0.79**	(0.38)	-0.34	(0.53)	0.27	(0.41)
Adjustment coefficient (ϕ)	-0.42***	(0.08)	-0.42***	(0.08)	-0.49***	(0.07)	-0.43***	(0.07)	-0.58***	(0.09)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.19***	(0.06)	-0.24***	(0.07)	-0.19***	(0.06)	-0.21***	(0.05)	-0.14	(0.09)
$\Delta ln(Y)_{t-2}$	-0.16***	(0.04)	-0.13***	(0.04)	-0.14***	(0.04)	-0.12***	(0.04)	-0.11**	(0.05)
$\Delta ln(NEER)_t$	0.05	(1.22)	-0.12	(0.98)	-1.19	(1.02)	-1.04	(1.03)	-1.20	(1.75)
$\Delta ln(NEER)_{t-1}$	-0.78	(1.67)	-0.73	(1.70)	-0.36	(1.57)	-0.22	(1.63)	-1.72	(2.16)
$\Delta ln(NEER)_{t-2}$	1.32	(1.22)	-0.77	(1.23)	-0.51	(1.09)	-0.38	(1.39)	-2.99**	(1.49)
$\Delta ln(REGDP)_t$	-0.96**	(0.48)	-0.25	(0.74)	0.18	(0.68)	-0.04	(0.81)	-0.20	(1.46)
$\Delta ln(REGDP)_{t-1}$	0.84	(0.59)	0.86	(0.62)	0.54	(0.71)	1.17**	(0.56)	1.65*	(0.86)
$\Delta ln(REGDP)_{t-2}$	0.78*	(0.42)	-0.53	(0.53)	-0.15	(0.70)	0.24	(0.67)	0.17	(0.91)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	759		759		759		759		667	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.28: Results for real exchange rates with time fixed effects excluding tourists from Japan and Russia

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.05	(0.27)	-0.97***	(0.29)	0.23	(0.28)	-0.06	(0.31)	1.06***	(0.36)
$ln(REGDP)_{t-1}$	-2.29***	(0.31)	0.56**	(0.26)	1.10***	(0.37)	-0.09	(0.45)	0.12	(0.38)
Adjustment coefficient (ϕ)	-0.40***	(0.07)	-0.39***	(0.07)	-0.48***	(0.06)	-0.42***	(0.06)	-0.61***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.20***	(0.05)	-0.26***	(0.06)	-0.20***	(0.06)	-0.23***	(0.05)	-0.12	(0.08)
$\Delta ln(Y)_{t-2}$	-0.18***	(0.04)	-0.15***	(0.04)	-0.15***	(0.04)	-0.15***	(0.04)	-0.11**	(0.05)
$\Delta ln(REER)_t$	-0.27	(0.87)	-0.84	(1.35)	-1.05	(1.19)	-0.76	(1.20)	-0.05	(1.46)
$\Delta ln(REER)_{t-1}$	-1.14	(1.49)	-1.07	(1.76)	-0.12	(1.57)	-0.28	(1.71)	-2.68	(2.45)
$\Delta ln(REER)_{t-2}$	0.95	(1.47)	0.10	(1.56)	-0.04	(1.28)	0.80	(2.01)	-1.54	(1.90)
$\Delta ln(REGDP)_t$	-0.69	(0.48)	0.15	(0.68)	0.27	(0.52)	-0.02	(0.61)	-0.89	(1.04)
$\Delta ln(REGDP)_{t-1}$	0.71	(0.56)	0.57	(0.52)	0.11	(0.53)	0.68	(0.47)	0.69	(0.74)
$\Delta ln(REGDP)_{t-2}$	0.95**	(0.40)	-0.33	(0.46)	-0.15	(0.58)	0.12	(0.59)	-0.54	(0.64)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.29: Results for nominal exchange rates with time fixed effects excluding tourists from Japan and Russia

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-1.26***	(0.27)	-0.79***	(0.19)	0.17	(0.20)	-0.16	(0.21)	0.79***	(0.25)
$ln(REGDP)_{t-1}$	-1.10***	(0.39)	0.73***	(0.27)	0.93**	(0.39)	0.14	(0.48)	0.19	(0.36)
Adjustment coefficient (ϕ)	-0.40***	(0.07)	-0.39***	(0.08)	-0.46***	(0.06)	-0.42***	(0.07)	-0.61***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.19***	(0.05)	-0.25***	(0.06)	-0.20***	(0.05)	-0.22***	(0.05)	-0.12	(0.09)
$\Delta ln(Y)_{t-2}$	-0.18***	(0.04)	-0.15***	(0.05)	-0.15***	(0.04)	-0.14***	(0.04)	-0.10**	(0.05)
$\Delta ln(NEER)_{t}$	0.33	(1.16)	-0.51	(0.98)	-0.76	(0.95)	-0.72	(1.01)	-0.26	(1.49)
$\Delta ln(NEER)_{t-1}$	-0.90	(1.73)	-0.88	(1.84)	-0.77	(1.87)	-0.65	(1.92)	-2.57	(2.19)
$\Delta ln(NEER)_{t-2}$	1.38	(1.30)	-0.34	(1.31)	-0.17	(1.29)	0.11	(1.55)	-2.71**	(1.29)
$\Delta ln(REGDP)_{t}$	-0.58	(0.46)	0.08	(0.63)	0.24	(0.48)	0.10	(0.58)	-0.64	(1.08)
$\Delta ln(REGDP)_{t-1}$	0.35	(0.56)	0.62	(0.54)	0.26	(0.60)	0.74	(0.50)	1.17	(0.76)
$\Delta ln(REGDP)_{t-2}$	0.53	(0.41)	-0.34	(0.41)	-0.01	(0.55)	0.14	(0.55)	0.13	(0.69)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.30: Results for real exchange rates with time fixed effects and a constant exchange rate for Swiss tourists

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	-0.40	(0.27)	-0.83***	(0.22)	-0.40*	(0.23)	-2.40***	(0.32)	0.42	(0.27)
$ln(REGDP)_{t-1}$	-2.20***	(0.30)	0.77***	(0.26)	1.47***	(0.34)	3.40***	(0.48)	0.17	(0.39)
Adjustment coefficient (ϕ)	-0.42***	(0.07)	-0.40***	(0.07)	-0.48***	(0.06)	-0.37***	(0.06)	-0.56***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.21***	(0.05)	-0.26***	(0.06)	-0.21***	(0.06)	-0.29***	(0.05)	-0.17**	(0.08)
$\Delta ln(Y)_{t-2}$	-0.18***	(0.04)	-0.16***	(0.05)	-0.16***	(0.04)	-0.17***	(0.04)	-0.13***	(0.05)
$\Delta ln(REER)_t$	0.22	(0.68)	0.28	(1.13)	0.20	(0.98)	0.24	(1.03)	0.15	(1.58)
$\Delta ln(REER)_{t-1}$	-0.40	(0.99)	-0.43	(0.81)	0.43	(0.72)	0.64	(0.72)	-0.03	(1.02)
$\Delta ln(REER)_{t-2}$	-0.13	(0.90)	-0.06	(0.62)	-0.28	(0.77)	-0.10	(0.83)	-0.71	(1.07)
$\Delta ln(REGDP)_t$	-0.48	(0.57)	-0.05	(0.77)	0.19	(0.61)	0.39	(0.73)	-1.39	(1.15)
$\Delta ln(REGDP)_{t-1}$	0.62	(0.58)	0.33	(0.62)	0.13	(0.61)	0.06	(0.56)	0.98	(0.83)
$\Delta ln(REGDP)_{t-2}$	1.04**	(0.48)	-0.81	(0.56)	-0.48	(0.70)	-1.01	(0.74)	-0.65	(0.74)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.31: Results for nominal exchange rates with time fixed effects and a constant exchange rate for Swiss tourists

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-0.81***	(0.19)	-0.59***	(0.12)	-0.09	(0.12)	-0.30**	(0.13)	0.40**	(0.17)
$ln(REGDP)_{t-1}$	-1.46***	(0.37)	0.94***	(0.25)	1.22***	(0.38)	1.01**	(0.47)	0.20	(0.36)
Adjustment coefficient (ϕ)	-0.40***	(0.07)	-0.40***	(0.07)	-0.47***	(0.06)	-0.42***	(0.07)	-0.60***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.19***	(0.05)	-0.24***	(0.06)	-0.19***	(0.06)	-0.22***	(0.05)	-0.13	(0.09)
$\Delta ln(Y)_{t-2}$	-0.18***	(0.04)	-0.15***	(0.05)	-0.14***	(0.04)	-0.13***	(0.04)	-0.10**	(0.05)
$\Delta ln(NEER)_t$	0.22	(0.97)	-0.07	(0.75)	-0.68	(0.76)	-0.51	(0.79)	-0.47	(1.25)
$\Delta ln(NEER)_{t-1}$	-0.32	(1.31)	-0.64	(1.37)	-0.47	(1.34)	-0.52	(1.38)	-1.00	(1.58)
$\Delta ln(NEER)_{t-2}$	1.33	(0.82)	0.05	(0.87)	0.16	(0.93)	0.41	(1.07)	-1.96*	(1.04)
$\Delta ln(REGDP)_t$	-0.82	(0.50)	-0.24	(0.71)	0.06	(0.59)	0.01	(0.75)	-0.75	(1.35)
$\Delta ln(REGDP)_{t-1}$	0.46	(0.59)	0.56	(0.64)	0.29	(0.67)	0.60	(0.55)	1.16	(0.89)
$\Delta ln(REGDP)_{t-2}$	0.41	(0.46)	-0.77	(0.52)	-0.37	(0.63)	-0.31	(0.61)	-0.12	(0.83)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.32: Results for real exchange rates with time fixed effects and ex-ante fixed shares

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.56	(1.06)	2.07**	(0.89)	8.19***	(1.51)	7.82***	(1.98)	13.16***	(4.66)
$ln(REGDP)_{t-1}$	-9.57***	(1.68)	-1.42	(1.14)	-1.11	(2.17)	-3.58	(2.71)	39.40***	(10.14)
Adjustment coefficient (ϕ)	-0.30***	(0.07)	-0.32***	(0.08)	-0.36***	(0.10)	-0.28***	(0.07)	-0.17*	(0.09)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.35***	(0.07)	-0.39***	(0.07)	-0.31***	(0.08)	-0.39***	(0.05)	-0.60***	(0.08)
$\Delta ln(Y)_{t-2}$	-0.34***	(0.06)	-0.31***	(0.08)	-0.27***	(0.08)	-0.29***	(0.06)	-0.48***	(0.07)
$\Delta ln(Y)_{t-3}$	-0.21***	(0.04)	-0.24***	(0.05)	-0.14**	(0.06)	-0.22***	(0.05)	-0.28***	(0.07)
$\Delta ln(REER)_{t}$	2.37	(1.77)	3.44**	(1.66)	1.14	(1.31)	1.68	(1.41)	3.91	(2.92)
$\Delta ln(REER)_{t-1}$	-0.55	(2.00)	2.11**	(0.96)	1.79	(1.93)	1.42	(1.34)	3.53	(2.57)
$\Delta ln(REER)_{t-2}$	3.70	(2.42)	0.01	(1.62)	-2.11	(1.72)	-1.70	(1.63)	1.11	(4.30)
$\Delta ln(REER)_{t-3}$	2.28**	(1.08)	0.60	(1.43)	-1.57	(1.49)	-1.44	(2.22)	0.00	(2.48)
$\Delta ln(REGDP)_{t}$	15.70	(10.85)	9.27	(8.55)	12.45**	(6.15)	11.47	(7.45)	-0.53	(6.99)
$\Delta ln(REGDP)_{t-1}$	12.71	(10.72)	7.31	(8.35)	17.83*	(10.37)	14.51	(9.35)	-6.99	(6.38)
$\Delta ln(REGDP)_{t-2}$	17.98	(14.83)	7.03	(9.93)	13.61	(8.85)	13.71	(9.37)	-5.74	(6.89)
$\Delta ln(REGDP)_{t-3}$	16.63	(11.53)	15.75**	(7.25)	20.97**	(9.91)	20.62*	(11.22)	14.72	(11.72)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.33: Results for nominal exchange rates with time fixed effects and ex-ante fixed shares

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-2.77***	(0.82)	-0.10	(0.57)	1.22**	(0.60)	1.76***	(0.65)	3.69***	(0.66)
$ln(REGDP)_{t-1}$	1.33	(2.40)	1.39	(1.64)	1.81	(1.41)	2.16	(1.57)	-6.17***	(1.91)
Adjustment coefficient (ϕ)	-0.33***	(0.08)	-0.33***	(0.08)	-0.46***	(0.10)	-0.37***	(0.09)	-0.59***	(0.15)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.32***	(0.07)	-0.39***	(0.08)	-0.24***	(0.08)	-0.32***	(0.07)	-0.19	(0.12)
$\Delta ln(Y)_{t-2}$	-0.32***	(0.05)	-0.31***	(0.08)	-0.23***	(0.07)	-0.25***	(0.07)	-0.17*	(0.09)
$\Delta ln(Y)_{t-3}$	-0.19***	(0.05)	-0.24***	(0.05)	-0.12**	(0.05)	-0.19***	(0.05)	-0.09	(0.06)
$\Delta ln(NEER)_{t}$	2.79	(2.66)	3.47	(2.13)	1.42	(1.99)	0.74	(1.65)	3.95*	(2.39)
$\Delta ln(NEER)_{t-1}$	-0.23	(2.74)	2.75**	(1.14)	3.74*	(2.15)	3.16*	(1.87)	3.53	(2.69)
$\Delta ln(NEER)_{t-2}$	5.88	(4.14)	-0.33	(1.69)	-1.46	(1.73)	-2.26	(2.08)	0.00	(2.97)
$\Delta ln(NEER)_{t-3}$	2.65**	(1.27)	1.16	(1.46)	0.41	(1.52)	-0.03	(2.36)	-0.12	(1.61)
$\Delta ln(REGDP)_{t}$	11.98*	(7.04)	7.74	(7.69)	11.86*	(6.48)	13.25	(8.75)	-1.01	(8.40)
$\Delta ln(REGDP)_{t-1}$	9.98	(9.56)	5.02	(6.50)	12.73	(8.53)	12.17	(9.35)	3.21	(7.79)
$\Delta ln(REGDP)_{t-2}$	13.11	(11.73)	3.76	(8.93)	9.62	(7.34)	11.01	(9.01)	-2.03	(7.78)
$\Delta ln(REGDP)_{t-3}$	13.22	(8.90)	15.77**	(7.45)	19.10**	(9.38)	21.41*	(11.53)	20.74	(13.94)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Linear time trend	No		No		No		No		No	
Observations	832		832		832		832		728	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.34: Results with average real exchange rates

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(REER)_{t-1}$	0.32	(0.55)	-2.91***	(0.50)	-0.01	(0.32)	0.41	(0.39)	-0.44	(0.55)
$ln(REGDP)_{t-1}$	-0.09	(0.26)	0.82***	(0.16)	1.32***	(0.11)	1.03***	(0.13)	1.51***	(0.19)
$ln(AVREER)_{t-1}$	0.35	(0.54)	3.52***	(0.53)	0.59*	(0.33)	0.14	(0.41)	1.15**	(0.55)
Adjustment coefficient (ϕ)	-0.36***	(0.07)	-0.42***	(0.08)	-0.63***	(0.12)	-0.51***	(0.09)	-0.57***	(0.10)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.19***	(0.04)	-0.23***	(0.06)	-0.11	(0.08)	-0.17***	(0.06)	-0.16**	(0.07)
$\Delta ln(Y)_{t-2}$	-0.20***	(0.04)	-0.10**	(0.05)	-0.02	(0.05)	-0.04	(0.05)	-0.16***	(0.05)
$\Delta ln(REER)_{t}$	1.71	(1.26)	1.31	(1.76)	2.30	(1.69)	2.99*	(1.72)	0.44	(1.89)
$\Delta ln(REER)_{t-1}$	-1.57	(1.26)	-1.14	(0.94)	-0.22	(0.74)	-0.92	(0.65)	-0.95	(1.61)
$\Delta ln(REER)_{t-2}$	0.91	(1.17)	-0.38	(1.08)	0.10	(1.37)	-0.67	(1.40)	-0.97	(1.46)
$\Delta ln(REGDP)_{t}$	-0.34**	(0.14)	-0.01	(0.17)	0.08	(0.18)	0.09	(0.18)	-0.04	(0.18)
$\Delta ln(REGDP)_{t-1}$	0.37**	(0.18)	0.13	(0.16)	0.07	(0.23)	0.23	(0.21)	0.30	(0.29)
$\Delta ln(REGDP)_{t-2}$	-0.01	(0.16)	0.13	(0.18)	0.26	(0.21)	0.34*	(0.21)	0.06	(0.23)
$\Delta ln(AVREER)_{t}$	-1.48	(1.22)	-0.99	(1.77)	-1.94	(1.65)	-2.61	(1.68)	-0.03	(1.89)
$\Delta ln(AVREER)_{t-1}$	1.40	(1.22)	1.09	(0.96)	0.36	(0.73)	1.15*	(0.63)	0.98	(1.65)
$\Delta ln(AVREER)_{t-2}$	-0.81	(1.29)	0.33	(1.17)	-0.14	(1.44)	0.74	(1.51)	0.93	(1.51)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Table 3.A.35: Results with average nominal exchange rates

Dependent Variable (Y):	**Arrivals**		**Nights**		**Bed OR**		**Room OR**		**Revenues**	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Long-run coefficients										
$ln(NEER)_{t-1}$	-1.11***	(0.21)	-1.75***	(0.25)	-1.79***	(0.27)	1.04***	(0.15)	-2.87***	(0.53)
$ln(REGDP)_{t-1}$	0.39*	(0.21)	0.99***	(0.14)	1.37***	(0.12)	1.73***	(0.09)	1.85***	(0.17)
$ln(AVNEER)_{t-1}$	1.67***	(0.22)	2.10***	(0.25)	2.39***	(0.28)	-0.79***	(0.16)	3.58***	(0.51)
Adjustment coefficient (ϕ)	-0.39***	(0.07)	-0.44***	(0.09)	-0.53***	(0.11)	-0.52***	(0.12)	-0.49***	(0.11)
Short-run coefficients										
$\Delta ln(Y)_{t-1}$	-0.17***	(0.06)	-0.21***	(0.06)	-0.17**	(0.07)	-0.14*	(0.08)	-0.23***	(0.08)
$\Delta ln(Y)_{t-2}$	-0.17***	(0.04)	-0.10**	(0.05)	-0.04	(0.05)	-0.05	(0.05)	-0.19***	(0.06)
$\Delta ln(NEER)_{t}$	-0.10	(1.62)	-0.46	(1.50)	0.04	(1.69)	1.49	(1.57)	-1.48	(1.99)
$\Delta ln(NEER)_{t-1}$	-0.74	(1.53)	-0.67	(1.33)	-0.92	(1.47)	-0.95	(1.34)	-3.12*	(1.85)
$\Delta ln(NEER)_{t-2}$	-0.04	(1.56)	-1.71	(1.90)	-0.78	(1.58)	-0.79	(2.02)	-1.48	(1.62)
$\Delta ln(REGDP)_{t}$	-0.20*	(0.11)	0.13	(0.16)	0.16	(0.19)	0.27	(0.17)	0.20	(0.20)
$\Delta ln(REGDP)_{t-1}$	0.30*	(0.18)	0.17	(0.15)	0.10	(0.22)	-0.02	(0.21)	0.39	(0.31)
$\Delta ln(REGDP)_{t-2}$	0.13	(0.14)	0.24	(0.18)	0.37*	(0.21)	0.24	(0.19)	0.28	(0.24)
$\Delta ln(AVNEER)_{t}$	0.44	(1.64)	0.79	(1.48)	0.44	(1.65)	-1.02	(1.54)	2.25	(2.03)
$\Delta ln(AVNEER)_{t-1}$	0.62	(1.50)	0.59	(1.33)	1.08	(1.44)	1.20	(1.32)	3.41*	(1.82)
$\Delta ln(AVNEER)_{t-2}$	0.11	(1.60)	1.81	(1.92)	0.76	(1.72)	1.11	(2.10)	1.46	(1.83)
Canton fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	No		No		No		No		No	
Linear time trend	Yes		Yes		Yes		Yes		Yes	
Observations	858		858		858		858		754	

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are seasonally adjusted for every canton prior to the estimation. Standard errors are corrected accordingly.

Part III

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